Economic Instruments for NO_x Emissions from Mobile Sources in Quebec: A Preliminary Investigation

Prepared for:

Environment Canada

Final Report

December 2, 1994

Prepared by:

APOGEE RESEARCH

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International, Ltd.

December 2, 1994

Mr. Jean Tremblay
Air Pollution and Toxic Substances Control
Quebec Region
Environment Canada

Ms. Judith Hull
Economic Analysis Branch
Environment Canada

Dear Jean and Judy:

RE: ECONOMIC INSTRUMENTS FOR NO_x EMISSIONS FROM MOBILE SOURCES IN QUEBEC: A PRELIMINARY INVESTIGATION

We are pleased to present our final report for this background study. Our major conclusions and recommendations are listed in Section 2 of the report.

We also note yesterday's release of the report of the Task Force on Economic Instruments and Disincentives to Sound Environmental Practices. Among the measures the Task Force recommends be "brought to the attention of Canadians" are:

- tax exemption for transit passes
- increased gasoline tax (measure without consensus)
- gas guzzler tax with rebate (measure without consensus)

The report also identified three "Measures for Longer Term Consideration" that are relevant to this study:

- incentives for alternative transportation fuels
- user pay road pricing
- fuel efficiency premiums

All of the above measures would impact NO_x emissions from mobile sources and could be included in the research following this report.

We enjoyed working with you on this project and wish you well with the subsequent study.

Sincerely

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Director, Environment-Economy

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1. Introduction

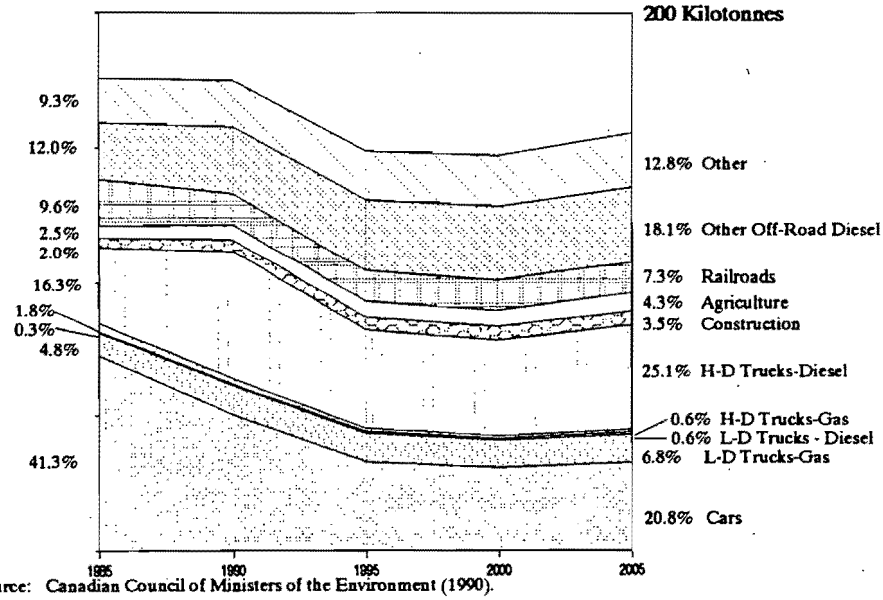
1.1 Background

Ground-level ozone is formed when nitrogen oxides (NO_x) react with volatile organic compounds (VOCs) in the presence of sunlight. At concentration levels currently experienced in some larger cities in Canada, ground-level ozone can adversely affect human health and damage crops and forests.

Canada has entered into international agreements to control NO_x emissions. To solve our domestic NO_x/VOCs-related environmental problems and meet our international obligations, the Canadian Council of Ministers of the Environment has created the NO_x/VOCs Management Plan. Phase I of the Plan, released in October 1990, developed 31 specific initiatives to be implemented by the federal and provincial governments.

In Quebec, the transportation sector accounts for 80% of NO_x emissions and 40% of the emissions of VOCs. These emissions come from both on-road vehicles and off-road sources such as railroads, construction and farm machinery, aircraft and ships. Exhibit 1.1 presents the NO_x emissions from mobile sources in Quebec.

Exhibit 1.1
NOx Emissions from Mobile Sources in Quebec



Source: Canadian Council of Ministers of the Environment (1990).

Economic instruments offer one approach to help achieve Canada's reduction goals for NO_x emissions. These policy options, such as tradeable permits and tax incentives, use market forces to encourage environmental protection. At the same time, economic instruments allow industry flexibility to achieve environmental goals in a cost effective manner.

The development of economic instruments dates back to the early 1930's with discussions of taxes to internalize the full costs of polluting behaviour. However, economic instruments did not receive widespread attention until in 1968 a Canadian economist, John Dales, published a seminal work that provided the theoretical underpinnings for economic instruments (Dales, 1968). Dales' work emerged at the beginning of unprecedented environmental regulatory activity and, consequently, unprecedented questioning of the effectiveness and efficiency of command-and-control regulations.

Canada's practical experience with economic instruments is growing rapidly. Many economic instruments are already in place, including: charges for extra-strength sewer discharges; inter-company trading programs for ozone-depleting substances; intra-utility trading of sulphur dioxide emissions; tax-financed management programs for scrap tires, lead-acid batteries and pesticide containers; curb-side disposal fees for solid waste; etc. Some of these examples go beyond the traditional government-administered economic instruments to include industry-administered economic instruments.

1.2 Objectives

Environment Canada is considering conducting a study of economic instruments to reduce NO_x emissions from mobile sources in the Quebec portion of the Windsor-Quebec City Corridor (WQC), one of Canada's major ozone non-attainment areas. The purpose of this report is to provide background information for the future study. More specifically, this report contains:

- a summary of major conclusions and recommendations (Section 2).
- a review of the objectives for NO_x emissions (Section 3);
- an analysis of sources of data that would be needed to assess economic instruments for NO_x emissions from mobile sources in Quebec (Section 4);
- a brief inventory of management programs for NO_x emissions, with conclusions as to how economic instruments could work with these programs (Section 5);
- descriptions of economic instruments that could be included in the study, with preliminary evidence of their effectiveness (Section 6); and
- discussions of several implementation issues pertinent to the study (Section 7).

2. Major Conclusions and Recommendations

Environmental Objectives

1. The NO_x/VOCs Management Plan indicates that emission reductions of over 70% will be needed to "consistently attain the 82 ppb [ozone concentration] standard throughout southern Ontario and southern Quebec." Furthermore, reductions of 30 to 50% "could be a significant step towards resolving peak ozone problems in the WQC."

2. Current and proposed initiatives are highly unlikely to achieve emission reductions of the magnitude required to achieve the federal and provincial ozone concentration standard.

3. The proposed study is compatible with the environmental objectives adopted by the Quebec government and the Montreal Urban Community.

Data Sources

4. There are no information gaps that would limit the ability to assess economic instruments for NO_x emissions from mobile sources in Quebec. Sufficient sources of background data on emissions, source characteristics and abatement costs exist.

Management Programs for NO_x Emissions

5. We identified no existing or proposed management programs that would limit the ability to implement economic instruments.

6. We recommend focusing the proposed study on on-road sources for three reasons. First, a significant portion of off-road emissions do not occur in urban centres where ozone problems are most severe. Second, emission reductions from off-road sources are limited by the technologies available from other countries (construction). Third, we identified few existing or proposed economic instruments for off-road sources.

   In 2005 without further initiatives, off-road sources will comprise just under 46% of NO_x emissions from mobile sources and about 33% of NO_x emissions from all sources.

7. Management programs frequently have economic incentives within them. This is particularly true for transportation control mechanisms (TCMs).

Economic Instruments

8. We identified 15 economic instruments to reduce NO_x emissions from mobile sources. They are ranked in Exhibit 2.1 according to the priority that we believe they deserve in the proposed study.

Exhibit 2.1
Economic Instruments for NO_x Emissions from Mobile Sources

High Priority

Emissions-Based Vehicle Registration Charge
Emissions-Based Vehicle Taxes
Vehicle Scrappage Program
Road Pricing
Parking Pricing

Moderate Priority

Fuel Efficiency Taxes on Vehicles
Government Procurement
Incentives for Buyers of Vehicles Running on Alternative Fuels
Reduction of Subsidies for Suburban Development

Low Priority

Incentives for New Vehicle Technologies
Enforcement Incentives for Inspection and Maintenance Programs
Incentives for Employer Transportation Management Programs
Fuel Taxes
Subsidies for Public Transit
Intra- and Inter-Company Averaging of Vehicle Emission Standards

9. Many of the economic instruments are not "stand-alone" instruments. Rather, the incentives are built into larger programs as one design feature. The proposed study can provide a preliminary evaluation of these economic instruments. However, they will also have to be evaluated within comprehensive studies of the design options for the larger programs.

10. Typically, economic instruments for mobile sources are not specific to one pollutant. *Consideration should be given to expanding the study to include all emissions affected by the instruments.* In particular, the costs of each instrument targeted to NO_x reduction should be evaluated against all the pollutants that will be reduced, not just NO_x.

11. There are many studies from other Canadian jurisdictions or for other pollutants (especially, greenhouse gases) that will assess similar instruments.

12. Canadian jurisdictions have significant experience with fuel taxes and energy efficiency taxes, but very little experience with market-based transportation control mechanisms.

13. U.S. and European jurisdictions have some experience with market-based transportation control mechanisms.

Implementation Issues

14. All levels of government -- federal, provincial and municipal -- have at their disposal economic instruments to reduce NO_x emissions from mobile sources.

15. None of the instruments ranked "high priority" are likely to be implemented by the federal government. However, the federal government could probably implement many of the other instruments.

16. Many of the instruments will not likely require enabling legislation. The exceptions are emissions-based vehicle charges, parking pricing and road pricing which may be constrained by current legislation.

17. We recommend that dispersion modelling *not* be required in the proposed study. Dispersion modelling should be undertaken for a complete package of control initiatives, including the selected economic instruments.

3. Objectives for NO_x Emissions

This section reviews the objectives for NO_x emissions and evaluates whether current initiatives may be sufficient to achieve these objectives. If current initiatives are insufficient, economic instruments for mobile sources may be useful to help reduce NO_x emissions from mobile sources in the Quebec portion of the WQC.

Phase I of the NO_x/VOCs Management Plan did not contain explicit emission reduction targets (CCME, 1990). Nonetheless, the Phase I Plan indicated that:

- "very large reductions in regional NO_x emissions (>70%) may be needed to consistently attain the 82 ppb standard throughout southern Ontario and southern Quebec"; and
- reducing NO_x and VOC emissions by 30 to 50% "could be a significant step towards resolving peak ozone problems in the WQC".

Interim (1995 and 2000) reduction targets were to be established in federal/provincial agreements for the three ozone non-attainment areas, including the WQC. The bilateral agreements are to be negotiated once the provinces have completed their consultation process. Bilateral negotiations between Quebec and Ontario are on hold while these provinces complete their consultations (Canadian Council of Ministers of the Environment, 1994; discussions with staff of the Air Issues Branch, Environment Canada).

Many of the national initiatives from Phase I of the Plan have already been implemented or are planned. Other initiatives have been rejected. Exhibit 3.1 summarizes the status of the national initiatives and the illustrative regional initiatives for Quebec.

Exhibit 3.1
Status of NO_x/VOCs Management Plan, Phase I Initiatives

	IMPLEMENTED	PLANNED	NOT PLANNED/UNKNOWN
National Prevention Program	N101 N102 N104 N105 N201 N202 N301 N302 N304 N305 N307	N303 N306	N103 (not planned) N308 (not planned)
Illustrative Regional Remediation Program (Status in Quebec)		N601 N603	N401 N501 N502 N503 N602 (not planned) N604 N605

Source: Air Issues Branch, Environment Canada.

It is difficult to determine the impact of these initiatives on NO_x emissions specifically from the Quebec portion of the WQC. The NO_x/VOCs Management Plan does not estimate the emission reductions from these initiatives for this sub-region. Instead, for each initiative, an estimate is provided of the expected NO_x reduction for the whole WQC. Exhibit 3.2 summarizes these emission reductions.

Exhibit 3.2
Expected NO_x Reductions in the WQC from Implemented or Planned Control Initiatives

INITIATIVE	NO_x REDUCTION IN WQC (KT in 2005)
Implemented	
N101: Power utility demand side management	0.0
N102: Energy efficiency in equipment, appliances	(combined with N101)
N104: Energy audits by industry	na
N105: Energy efficiency in buildings	1.6
N201: Public education - driving/alternative transport	na
N202: Public education - energy conservation	na
N301: LDV/LDT NO_x emission standards	29.9
N302: HDV NO_x emission standards	7.8
N304: Cap on NO_x emissions from rail transport	(in baseline forecast)
N305: NSPS - power plants	--
N307: NSPS - gas turbines	0.4
	TOTAL = 39.7
Planned	
N303: Construction diesel engines NO_x emission standards	3.5
N306: NSPS - industrial boilers	17.9
N601: LDV inspection and maintenance	4.4
N603: Retrofit - existing industrial boilers	2.8
	TOTAL = 28.6

Source: Canadian Council of Ministers of the Environment (1990) and Air Issues Branch, Environment Canada.

The question remains: are these NO_x reductions sufficient to achieve the goals of the NO_x/VOCs Management Plan? Exhibit 3.3 shows that the Phase I initiatives already implemented or planned are expected to reduce emissions in the WQC by less than 15% from 1985 levels. These reductions are significantly less than the 30-50% or 70% reductions mentioned in Phase I of the Plan.

Exhibit 3.3
Projected Emissions in the WQC
(kilotonnes)

Emissions in 1985	572.2
Emissions in 2005 (Pre-Plan)	564.7
Reductions from Implemented Initiatives	39.7
Reductions from Planned Initiatives	28.6
Emissions in 2005 with Implemented and Planned Initiatives	496.4
% Reduction from Implemented and Planned Initiatives	87%

Source: Canadian Council of Ministers of the Environment (1990) and exhibits above.

Fifteen percent may not represent the true NO_x reductions that are occurring. There are two reasons for this discrepancy:

- the Phase I initiatives may in fact result in different levels of reduction (e.g. Quebec's I&M program may reduce NO_x emissions by more than predicted in the Phase I Plan); and
- additional initiatives, not contained in the Phase I Plan, may be implemented by the provincial or municipal governments in Quebec (e.g., voluntary vehicle emission testing clinics have been held in Quebec).

It is, however, unlikely that either of these factors could achieve NO_x reductions of over 70%, as suggested in the Phase I Plan. Therefore, it appears that additional measures -- such as economic instruments for mobile sources -- may be useful.

Two additional issues were raised regarding the objectives adopted by different levels of government:

(i) Quebec's schedule for implementing provincial initiatives; and

(ii) the Montreal Urban Community's air quality standard.

Schedule of Provincial Initiatives

As mentioned above, neither Quebec nor Ontario -- the two provinces encompassing the WQC -- have negotiated NO_x reduction targets.

To date, Quebec has planned two provincial NO_x initiatives:

- *Initiative N601*: Light Duty Inspection and Maintenance (I&M) Program and Anti-Tampering Legislation; and
- *Initiative N603*: Retrofit of 50% of Existing Commercial/Industrial Boilers and Heaters to the NO_x Emission Levels of the 1994 New Source Performance Standards by 1997.

Options for an I&M program are currently under consideration by the provincial government. Initiative N603 is planned for 1995.

The provincial government has decided not to implement Initiative N602 -- new source performance standards for fossil fuelled power plants by 1995 and new source performance standards for existing fossil fuelled power plants by 1997.

We do not believe that the province's schedule has negative implications for the proposed study.

If, however, the province decides on the design of its I&M program prior to starting the proposed study, then one of the economic instruments -- enforcement incentives for I&M programs -- could be omitted from the study scope.

Air Quality Standards

The federal government has adopted an ozone concentration standard of 82 ppb measured on an hourly basis. The Montreal Urban Community has reportedly calculated its ozone concentration standard in such a way that the concentration is slightly different from the federal standard.

We foresee no problems for the proposed study emanating from this small difference in standards. No single economic instrument will exactly achieve the ozone concentration standard.

We recommend that the proposed study assess economic instruments to achieve reductions of NO_x emissions, *not* specified ozone concentrations. There are several reasons for this recommendation.

- The feasibility and effectiveness at reducing NO_x emissions of economic instruments should be thoroughly explored before undertaking costly dispersion modelling.

- Ozone modelling should be undertaken for reductions resulting from the many NO_x and VOCs initiatives in place or being considered. Modelling in isolation the impacts on ground-level ozone of economic instruments for mobile sources of NO_x is unlikely to yield accurate results.

- The NO_x/VOCs Management Plan amply demonstrates the scientific difficulties in measuring the reductions in ground-level ozone resulting from a given level of NO_x reduction.

4. Data Sources

Sources for three types of data were investigated: emissions; source characteristics; and abatement costs. There are no information gaps that must be filled before beginning the study.

Data on emissions and source characteristics are readily available. The major source will be Environment Canada's Transportation Systems Division. All data are available in hard copy. Emissions data and vehicle population can also be provided on disk (ASCII format).

DesRosiers Automobile Consultants will be a second useful source of data on source characteristics. This private consulting firm maintains large quantities of data derived from vehicle registration databanks and other sources. There will, however, be charges to access these data.

4.1 Emissions

Environment Canada's Transportation Systems Division maintains data on emissions from on-road mobile sources. NO_x emissions data are available for Quebec for the years 1985 through to 2020, in both tonnes per annum and grams per mile. This data is available per year for each of seven types of vehicles:

LDGV	Light Duty Gas Vehicles
LDGT	Light Duty Gas Trucks (0 to 8,500 lbs GVW)
HDGV	Heavy Duty Gas Vehicles (>8,500 lbs GVW)
LDDV	Light Duty Diesel Vehicles
LDDT	Light Duty Diesel Trucks (0 to 8,500 lbs GVW)
HDDV	Heavy Duty Diesel Vehicles (>8,500 lbs GVW)
MC	Motorcycles

The data are derived using MOBILE5C, an emissions modelling program that calculates emissions factors (grams/mile) per province for four seasonal scenarios for both highway and urban cycles. Two post-processing programs are used to weight the data into tonnes (based on fleet pollution and vehicle miles travelled) and grams/mile per year.

Off-road sources are not so well documented. The Residual Discharge information System contains data on 1985 emissions from rail, marine and aircraft sources. Preliminary 1990 estimates are held by the Pollution Data Analysis Division, but they have not yet been made public. More recent data on emissions from railroads are available from the Railway Association of Canada.

Environment Canada may choose to limit the study of economic instruments to on-road sources. There are several factors favouring this focusing decision.

(i) A significant percentage of off-road emissions are not located in urban population centres. Therefore, NO_x emissions from off-road sources may not be as important

a contributor to ground-level ozone exceedances as NO_x emissions from on-road sources.

(ii) The scope for reductions in off-road emissions beyond what is already contained in the Management Plan appears to be limited. For example, railroads account for most (about 65%) of the NO_x emissions from off-road sources. The NO_x/VOCs Management Plan states that there is little scope for emission reductions from the railroad sector:

> Given the current unavailability of better engine technology and the uncertain future timing of engine technology improvements that will reduce NO_x, the 14% emission reduction forecast represents a cost-effective current estimate of what can be achieved over the 1985 to 2005 time period. (Canadian Council of Ministers of the Environment, 1990)

The Plan also states that mandating cleaner diesel engines in the construction industry is dependent on regulatory developments in other jurisdictions where the diesel engines are manufactured.

(iii) As we shall see, many of the potential economic instruments do not address off-road emissions. This does not imply that economic instruments could not address off-road sources, but it does mean that there is little experience from which to identify potential instruments and evaluate their effectiveness.

As shown in Exhibit 3.4, off-road sources comprise just under 40% of NO_x emissions from mobile sources and about 20% of NO_x emissions from all sources.

Exhibit 3.4
Contribution of Off-Road Sources to NO_x Emissions

Share of Off-Road* Sources in NO_x Emissions from...	1985	1990	1995	2000	2005
Mobile Sources	35%	36%	44%	47%	46%
All Sources	28%	28%	32%	33%	33%

* We have defined "Off-Road" sources to include both "Off-Road Diesel" and "Other Transportation." Off-road *diesel* accounts for about 80% of total off-road emissions.

Source: Canadian Council of Ministers of the Environment (1990).

4.2 Source Characteristics

Fleet Size and Growth Rates: Environment Canada's Transportation Systems Division (TSD) maintains data on vehicle population and projected estimates for each of the seven vehicle types described above. These data, in the form of percentage growth from a base population, have been derived in-house using information from DesRosiers Automobile Consultants. Vehicle populations have been extrapolated to the year 2020.

Vehicle-Kilometres Travelled: MOBILE5C requires estimates of vehicle miles travelled, also estimated by the TSD. Estimates are available for each vehicle type, by province and for 1980-1988 (more recent estimates may also be available). A forecast of vehicle miles travelled could be extrapolated from this time series.

Vehicle Age Distribution: The TSD has created vehicle age distributions for a 25-year period using provincial vehicle registration data obtained from DesRosiers.

Vehicle Model Distribution: DesRosiers maintains data on vehicle manufacturers, compiled from vehicle registration databases.

Tampering Rates: Tampering rates are an input to the MOBILE5C model and are, therefore, available from the TSD.

Market Structure: In preliminary discussions with Environment Canada staff, the "market structure" relevant to mobile sources was defined as: number of vehicle retail outlets by company; and the brand-name composition of vehicles on the road. This information is available from DesRosiers and the Motor Vehicle Manufacturers' Association.

After reviewing the types of economic instruments available for controlling NO_x emissions from mobile sources, we believe that other types of "market structure" information will be more relevant. For example:

- the manufacturing location of cleaner engines and pollution control devices;
- the ability to import such technologies; and
- the availability of the fuels required by new technologies.

Identifying the specific information required and sources for that information will require detailed research. Likely sources include:

- Motor Vehicles Manufacturers' Association;
- Canadian Trucking Association;
- Canadian Petroleum Products Institute;
- Natural Resources Canada (Oil and Gas Branch);
- Transport Canada (Motor Vehicle Standards and Research); and
- Environment Canada (Transportation Systems Division).

Various price elasticities will also be required to evaluate the effectiveness of economic instruments. Price elasticities measure the responsiveness of companies, organizations and individuals to changes in the prices of goods and services. For example, suppose "gas guzzler" vehicles have an output price elasticity of -0.3. This implies that raising the price of gas guzzlers by 1% will reduce the demand for such vehicles by 0.3%.

In our experience, studies of economic instruments frequently do not have available price elasticities specific to the products and jurisdictions of interest. However, in the case of mobile sources, formal price elasticities for fuel consumption and use of public transit in Quebec are likely available. Elasticities for other relevant goods, services and activities are available from other jurisdictions. Numerous elasticities can be obtained or inferred from the studied referenced in this study. Their applicability to the Quebec portion of the WQC should be verified.

4.3 Abatement Costs

Costs of management programs will be needed to assess the potential to apply economic instruments to NO_x emissions from mobile sources in Quebec. The following sources provide starting points for estimating abatement costs:

- Initiative S301 NO_x/VOCs Management Plan (in progress);
- Apogee Research (1994c);
- B.H. Levelton (1992); and
- VHB Research and Consulting and Senes Consulting (1989, 1991).

Initiative S301 NO_x/VOCs Management Plan

The objective of Initiative S301 is to:

> provide a comprehensive review of costs, efficiencies, practical considerations and market experience relevant to often used Best Available Control Technologies associated with the reduction of NO_x and VOC emissions from all sources. (Terms of Reference, Environment Canada)

The project is in its initial stages, with completion expected by the end of March. The end result, a cost database, will contain a description of different control strategies (end-of-pipe pollution control devices, product and process changes, fuel composition changes, etc.) and, where possible, cost estimates.

The transportation sources covered include the following vehicle types:

Gasoline Powered Automobiles
Light Duty Gasoline Trucks
Heavy Duty Gasoline Trucks
Light Duty Diesel Trucks
Heavy Duty Diesel Trucks
Other Diesel Vehicles
Gasoline Powered Motorcycles

Off-road surface, marine and air transportation sources may also be included, depending on data availability.

Apogee Research (1994c)

This paper reviews over 50 recent U.S. studies on transportation control measures and provides cost estimates. Two types of estimates are provided:

(i) cost per vehicle round-trip avoided (assumed to be a "work trip" of 11 miles); and

(ii) cost per ton of hydrocarbons abated.

The TCMs covered in are: employer trip reductions; area wide ridesharing; transit improvements; high occupancy vehicle lanes; park-and-ride lots; bike-and-walk facilities; parking pricing; congestion pricing; signal timing; taxes on emissions/vehicle mile travelled (emissions-based vehicle registration charges); and buy-backs of older cars. Appendix B contains descriptions of these TCMs.

In reviewing these studies, Apogee (1994) reveals that few studies of TCMs focus on NO_x emissions. Instead, cost effectiveness is typically discussed in terms of cost per ton of hydrocarbons abated or, in some cases, cost per ton of several pollutants combined (NO_x and VOCs). The focus on hydrocarbons may be due to their health effects or to the fact that hydrocarbon reductions may be more effective in reducing ground-level ozone in *urban* areas.

Where estimates of the cost per ton of NO_x emissions abated are not available, we still provide estimates of the cost per ton of hydrocarbons (or total emissions). This figures may be of some use since many ways of reducing VOC emissions from mobile sources will also reduce NO_x emissions.

Caution must be exercised when extrapolating NO_x reductions from VOC reductions. The *magnitude* of reductions will vary across pollutants. For example, the NO_x/VOCs Management Plan indicates the motor vehicle inspection and maintenance programs will reduce VOC emissions by 16% and NO_x emissions by 4%.

B.H. Levelton & Associates (1992)

In developing the GVRD Air Quality Management Plan, B.H. Levelton provided an assessment of various transportation control mechanisms: parking management; ridesharing; employer-based transportation management; transit facilities and operations; transit management; high occupancy vehicle facilities; work location changes; etc. Cost estimates are available for some of these mechanisms.

VHB Research and Consulting and Senes Consulting

VHB Research and Consulting have undertaken two studies on the costs of reducing NO_x emissions from mobile sources.

(i) A 1991 study on reducing emissions from Ontario's energy sector developed cost estimates for several management programs, including inspection and maintenance programs, improved fuel economy, and provision of public transit (VHB Research and Consulting, 1991). However, many of these cost estimates are based on data from the early or mid 1980s and, therefore, may be out-of-date.

(ii) A 1989 study estimated cost per tonne of NO_x reduced for the following emission sources:

Gasoline Passenger Vehicles
Light Duty Gasoline Trucks
Heavy Duty Gasoline Trucks
Heavy Duty Diesel Trucks
Railroads
- New engines
- Existing engines

Marine
- Medium speed
- High speed
- Generator

Diesel Agriculture
- Small tractor
- Large tractor
- Combine

Diesel Agriculture
- Hydraulic excavator
- Industrial wheeled tractor
- Concrete paver

Given the age of this report, it may be necessary to up-date these cost estimates before using them in the proposed study.

Note that Environment Canada has contracted Senes Consulting to complete Initiative S301. Up-dates of the cost estimates in these older reports should be available by end of March.

5. Management Programs for NO_x Emissions

Management programs for NO_x emissions can contribute to achieving ground-level ozone concentration standards in four ways:

- *Improving Emission Performance*: reducing the emissions per vehicle-kilometre travelled by: using new, more effective pollution control devices; ensuring pollution control devices are working at maximum effectiveness; improving energy efficiency; changing travel speeds; etc.;

- *Altering the Composition of the Vehicle Fleet*: replacing vehicles with ones that are "cleaner" or more fuel efficient, including inter-modal substitution (e.g., public transit for private transit);

- *Reducing the Demand for Transportation*: reducing the vehicle-kilometres travelled by: increasing the number of high occupancy vehicles (HOVs); encouraging cycling and pedestrians; bring job locations and houses closer together; etc; and

- *Altering the Demand for Transportation*: shifting the temporal and/or spatial patterns of NO_x emissions to inhibit the formation of ground-level ozone. For example, transferring the number of vehicle-kilometres driven from peak hours to off-peak hours or from high traffic areas to low traffic areas can reduce ground-level ozone.

The first three ways reduce NO_x emissions, while the fourth approach involves reducing the impacts of NO_x emissions.

This section of the report compiles an inventory of management programs that are or could be used to achieve the above four purposes. Exhibit 5.1 lists the programs identified.

Note that the 1994 annual report of the NO_x/VOCs Management Plan also contains information on each of the Plan's initiatives. We do not repeat that information here.

Economic instruments are specifically examined in the next section of the report. However, as will be evident, many economic instruments are integral components of management programs that also encompass "command-and-control" measures and/or voluntary measures. Therefore, some economic instruments also appear in this section. Economic instruments are highlighted with bold text.

Exhibit 5.1
Management Programs for NO_x Emissions from Mobile Sources

Improving Emission Performance

Vehicle Inspection and Maintenance Programs
Anti-Tampering Programs
Vehicle Emission Standards
Fuel Efficiency Standards
Fuel Standards

Altering the Composition of the Vehicle Fleet

Mandatory Purchase of Vehicles Using Alternative Fuels
Fuel Standards to Ensure Alternative Fuels Are Available

Altering or Reducing Transportation Demand

Parking Management
Ridesharing
Employer-Based Transportation Management (Employer Trip Reduction)
Transit Facilities and Operations
Transit Management
Signal Timing
HOV Lanes
Telecommuting
Urban Planning
Cycling and Pedestrian Facilities
Park-and-Ride Facilities
Compressed Work Week
Incident Management

5.1 Improving Emission Performance

Major approaches to improving the emissions released per vehicle-kilometre travelled are:

- vehicle emission standards;
- fuel efficiency standards;
- fuel standards;
- vehicle inspection and maintenance programs; and
- anti-tampering programs.

Standards for motor vehicle emissions, vehicle fuel efficiency and fuel composition are largely a federal responsibility. For example, the NO_x/VOCs Management Plan recommended that the federal government promulgate:

- more stringent NO_x emission standards for new light duty vehicles and light duty trucks (N301);
- more stringent NO_x emission standards for new heavy duty vehicles (N302); and
- NO_x emission standards for diesel engines used in construction (N303).

Inspection and maintenance (I&M) and anti-tampering programs, on the other hand, are largely the responsibility of provincial governments. Initiative N601 of the NO_x/VOCs Management Plan recommended that I&M programs and anti-tampering legislation be developed and implemented in the Lower Fraser Valley and the Windsor-Quebec City Corridor by British Columbia, Ontario and Quebec.

The Management Plan estimated that I&M programs in the WQC would reduce NO_x emissions from light duty vehicles and trucks by 4% by the year 2005 (VOCs by 16%). As shown below, 4% is significantly less than the reductions expected from B.C.'s I&M program. Quebec's program is also likely to be as effective.

British Columbia's Motor Vehicle Branch has implemented the AirCare program -- a centralized vehicle inspection and exhaust analysis program for light duty gasoline vehicles. The program has the following features:

- centralized contractor-operated inspection and testing;
- computer-assisted identification of emission control components;

- comprehensive visual and functional inspections;
- both idle and loaded mode emission testing with capabilities for higher than normal loads;
- measurement of vehicle emissions of HC, CO, CO_2 and NO_x;
- extraction of fault codes from on-board computers on vehicles that fail the test;
- generation of diagnostic information and guidance to assist mechanics in the repair of failed vehicles;
- training and certification programs for mechanics;
- continuous monitoring of mechanics' performance and qualifications of certified mechanics; and
- a test facility to obtain information on program effectiveness by testing a sample of vehicles before and after repair;

Within three to five years of operation, AirCare alone is projected to reduce emissions from light duty vehicles by:

NO_x	20%
CO	30%
VOC	25%

The GVRD Air Quality Management Plan ranked different measures to reduce NO_x measures. The Plan recommended that AirCare receive the highest priority in the short term for reducing NO_x emissions (B.H. Levelton & Associates, 1992).

Ontario has implemented a test I&M program. This project is being jointly run by the Ministry of Transportation and the Ministry of Environment and Energy. It is still in the planning stages, but the following information was made available.

The program will establish a system of remote sensing to document which light passenger vehicles are "dirtiest" with regards to emissions levels. This program will begin its trial phase in late 1994 and will have a duration of one year. The U.S. EPA I.M. 240 standard will be implemented.

The program will consist of voluntary testing for passenger vehicles. This testing will take place at a single test station within the Metropolitan Toronto area. The program's goal is the testing of a minimum 25,000 vehicles over the one year period. From the information gathered in these tests, a database of vehicle models, years and emissions standards will be constructed.

Due to the voluntary nature of the pilot program, the emphasis will be placed on the communication and education of the public. Public understanding of the issues involved is central to the program's success and its continuation.

After the one year trial period, a system of mandatory testing with a network of stations will be implemented. The initial station will test only light vehicles. However, there is currently a remote sensing unit on Highway 401 for voluntary testing of heavy duty diesel trucks.

An evaluation of the Ontario program will be available in January 1995.

Quebec has developed alternative designs for an I&M program. The government is currently deciding upon the preferred design.

New Brunswick and Nova Scotia are also initiating an I&M program scheduled for late 1994 or early 1995.

5.2 Altering the Composition of the Vehicle Fleet

The composition of the fleet refers to both the vehicle age and model. Typically, age and vehicle model determine the type of pollution control device installed, the deterioration rate of the pollution control devices and, in some cases, the grade of fuel used.

There are very few management programs that seek to directly alter the composition of the vehicle fleet. Indeed, the only program identified was California's regulations requiring certain levels of sales of electric vehicles (Concord Environmental, 1991).

A second program that indirectly influenced fleet composition was also identified, namely Environment Canada's efforts to ensure that low sulphur diesel fuel is made available in Canada. Without such a fuel, Canadian trucking companies would not be able to purchase new, cleaner engines now being produced in the United States. The Department's efforts resulted in a voluntary agreement with the petroleum refining industry to supply low-sulphur diesel fuel.

Economic instruments -- predominantly tax measures -- are available and used to help change the composition of vehicle fleets. These are discussed in the next section of this report.

5.3 Reducing and Altering Transportation Demand

Policies to reduce or alter transportation demand are now called "transportation control measures." As one study states:

> In one form or another, transportation control measures (TCMs) have been part of urban transportation discussion for the last thirty years. While the term "TCM" is comparatively new, it overlaps with what has long been called travel demand management or, more generally, transportation systems management. Regardless of the name, one major goal of these techniques is to encourage more efficient use of existing highway networks without major investment. In general, this is done by improving flows and by restraining demand or deflecting it away from crowded facilities at peak-volume times. (Apogee Research, 1994)

A more recent use of TCMs is to help achieve air quality goals. Under the 1990 amendments to the U.S. Clean Air Act, restraint of automobile travel through TCMs is a principal means of reducing emissions. Each ozone non-attainment area (except those designated as "marginal") must include TCMs as part of a contingency plan to reduce emissions. One specific TCM -- employer-based trip reduction programs for firms with 100 or more workers -- is *required* for severe and extreme ozone non-attainment areas.

Much work has been done on individual TCMs. Several studies have attempted to pull together the existing work and make comparisons among TCMs. Below, we summarize the results from these two studies.

TCMs cross the traditional classes of environmental policies: voluntary measures, "command-and-control" measures and economic instruments. Economic incentives are frequently an integral component of a TCM. Therefore, in summarizing two studies of TCMs, we have not attempted to separate economic instruments from other TCMs. We do, however, highlight TCMs that could be called economic instruments (in bold in the exhibits below).

B.H. Levelton (1992)

One recent study of TCMs was conducted for the Greater Vancouver Regional District (B.H. Levelton, 1992). From a review of existing TCMs (largely in the U.S.), the study identified the TCMs listed in Exhibit 5.2.

Estimates of the TCMs' potential effectiveness if applied in the GVRD were also developed. Exhibit 5.3 presents the range of emission reductions achieved in other regions, as well as the potential emission reductions for GVRD in the short term and long term. If the complete set of TCMs were implemented in 1992, the study predicts emission reductions of 7% by 1995 and 20% by 2005.

Exhibit 5.2
Transportation Control Measures

Parking Management

- Zoning restrictions on number of parking spaces
- Mandatory reserved parking for high occupancy vehicles
- Capping number of parking spaces in city centres
- **Parking levies and taxes**
- **Occupancy-based parking rates**
- **Reduction of parking subsidies**
- **Higher fines for illegal parking**

Ridesharing

- Car pooling
- Van pooling
- Bus pooling
- Voluntary/education

Employer-Based Transportation Management

- Mandated average vehicle ridership rate based on business location
- Parking management
- Work schedule changes (compressed work week)
- Location changes
- Telecommuting
- **Transportation allowances or subsidies**
- **Reduced parking rates for pool vehicles**

Transit Facilities and Operations

- HOV lanes
- Road and signal preemption for transit vehicles
- Park and ride facilities
- Improved schedule coordination
- Expansion of systems
- Improved amenities

Transit Management

- Vehicle maintenance
- Choice of transit vehicle
- **Fare reductions**

HOV Management

- HOV lanes
- Provision of park and ride lots

Work Location Changes

- Telecommuting

Urban Planning

- Regional town centres

Cycling and Pedestrian Facilities

- Increased routes
- Provision of bicycle parking, showering, etc.
- Improved safety

Note: Bold text denotes market-based TCMs.

Source: B.H. Levelton & Associates (1992).

Exhibit 5.3
Emission Reduction Potential of TCMs Applied in the GVRD

Category of TCM	% Reduction in Total Emissions (SO_x, NO_x, PM, CO, VOC, road dust)		
	Range from Literature Review	*Phase A (Pre-1995)*	*Phase B (Post-1995)*
Parking Management	0.6% to 2.4%	0.7%	1.5%
Ridesharing	0.5% to 2%	1.0%	1.7%
Employer-Based Transportation Management	1.4% to 8%	3.0%	5.0%
Transit Facilities and Operations	0.3% to 3%	0.5%	1.6%
Transit Management	<1% to 4%	0.7%	2.0%
HOV Management	<1% to 2%	0.3%	2.0%
Work Location Changes (Telecommuting)	0.3% to 1.7%	0.5%	1.0%
Urban Planning	3% to 7%	0.0%	5.0%
Cycling and Pedestrian Facilities	<1 to 2%	0.3%	1.0%
Total	6% to 32%	7.0%	20.0%

Notes: NO_x accounts for about 8% of the GVRD's 586 kilotonnes of total emissions.

Potential emission reductions could be much higher depending on regional transportation policy regarding new highway/transit facilities.

Competing and complementary effects among TCMs are difficult to predict and, therefore, total percent reductions are approximate.

Phase A reductions and Phase B reductions are *not* additive. There will not, for example, be a total emission reduction of 27% after 1995.

Source: B.H. Levelton (1992).

Apogee Research (1994c)

A second recent study, Apogee Research (1994c), reviewed 50 U.S. studies of TCMs. The study identified 15 types of TCMs and classified them according to their effectiveness in reducing hydrocarbon (HC) emissions and cost effectiveness. Exhibit 5.4 presents the major findings.

Market-based TCMs (in bold) are found to be the most effective TCMs in reducing emissions. In addition, the cost effectiveness of market-based TCMs is high or moderate.

However, the study cautions readers about the lack of certainty regarding the effectiveness of TCMs:

> *How* the TCMs are put into place (e.g. how they are communicated to the public, the timing of their implementation, etc.) may have as much to do with their eventual effectiveness as the specifics of *what* is done. (Apogee Research, 1994c)

The study also recommends interpreting the cost estimates only as measures of the *relative* cost of the measures. The individual estimates for each TCM may vary considerably across regions or applications.

5.4 Conclusions

This brief review of management programs for NO_x emissions yields a number of conclusions.

- We identified no existing or proposed management programs that would limit the ability to implement economic instruments.
- The direct role of the federal government is currently limited to standards on vehicle emissions, fuel efficiency and fuel composition.
- Economic incentives can be incorporated into many of the management programs. That is, the economic incentives would *not* be "stand-alone" instruments but would be a design feature of a larger program. For example, vehicle inspection and maintenance programs could include fines and/or fees.
- Transportation control measures, especially, include both market-based and non-market-based measures. For example, a parking management strategy would likely include adjustments to parking charges, as well as zoning restrictions, capping, etc.
- TCMs are usually examined in the context of an urban transportation management plan, rather than a study specifically on economic instruments. Studying market-based TCMs within the context of such a plan allows the integration of many policy areas: energy supply; urban development; traffic control; public transit; air quality; etc.

Exhibit 5.4
Environmental and Cost Effectiveness of Transportation Control Measures in Reducing Hydrocarbons

Cost Effectiveness	Environmental Effectiveness		
	Strong (HC Reduction > 2%)	*Weak (HC Reduction < 1.1%)*	*Speculative*
High (< $25,000/ton of HC)	**Emissions/VMT Tax** **Buy-backs of Older Cars**	Signal Timing Area-wide Ridesharing	
Moderate ($25,000-$100,000/ton of HC)	**Congestion Pricing** **Parking Pricing**	Incident Management	
Low (> $100,000/ton of HC)		HOV Lanes Park-and-Ride Lots Transit Improvement Employer Trip Reduction Bike and Walk Facilities	
Unknown but Likely High			Land Use Planning Telecommuting Compressed Work Week

Notes: All figures are in U.S. dollars.
Bold text denotes market-based TCMs.

Source: Apogee Research (1994c).

6. Economic Instruments for NO_x Emissions from Mobile Sources

Studies of economic instruments are often criticized for being too general and theoretical. Practical design and implementation issues are frequently neglected. One approach to addressing the lack of detailed analysis is to focus project resources on a smaller subset of instruments that pass a preliminary screening.

This section of the report serves two purposes:

(i) to develop a menu of economic instruments that could be applied to NO_x emissions from on-road sources; and

(ii) to provide a preliminary indication of what instruments appear to be the most environmentally and cost effective.

Based on the studies reviewed for this report, environmental effectiveness is measured as potential reductions in emissions. In most cases, estimates of emission reductions are not available for NO_x specifically. Instead, estimates of reductions in hydrocarbons or total emissions are reported. As described earlier, reductions NO_x emissions will be related to reductions in other pollutants, but not necessarily of the same magnitude.

Cost effectiveness is then measured as the cost of reducing each tonne of hydrocarbons or total emissions.

Exhibit 6.1 presents a list of the potential economic instruments identified in this background study. While other economic instruments can be envisioned, these are the ones that we identified in our literature review.

Note that additional information on these instruments will be available soon from various current sources. These sources include:

- ARA Consulting Group: A General Plan for Incorporating Economic Instruments into the GVRD Air Quality Management Plan Goals;"
- the work of the federal Task Force on Economic Instruments and Disincentives to Sound Environmental Practices; and
- on-going research into measures to reduce greenhouse gas emissions.

Environment Canada's proposed study should take advantage of these other research efforts.

Exhibit 6.1
Economic Instruments for NO_x Emissions from Mobile Sources

High Priority

Emissions-Based Vehicle Registration Charge
Emissions-Based Vehicle Taxes
Vehicle Scrappage Program
Road Pricing
Parking Pricing

Moderate Priority

Energy Efficiency Taxes on Vehicles
Government Procurement
Incentives for Buyers of Vehicles Running on Alternative Fuels
Reduction of Subsidies for Suburban Development

Low Priority

Incentives for New Vehicle Technologies
Enforcement Incentives for Inspection and Maintenance Programs
Incentives for Employer Transportation Management Programs
Fuel Taxes
Subsidies for Public Transit
Emission Charges for Aircraft
Road-User Charges for Heavy-Duty Vehicles
Intra- and Inter-Company Averaging of Vehicle Emission Standards

For each of the economic instruments listed in Exhibit 6.1, we provide:

- a brief discussion of the instrument;
- a summary of evidence of the instrument's environmental and cost effectiveness;

and

- the priority ranking of the instruments (high, moderate, low).

The ranking system refers to our judgement of the priority that should be given to the economic instrument in the proposed study. In developing the ranking, we took three main considerations into account: environmental effectiveness; cost effectiveness; and feasibility. We are continuing to investigate two potential economic instruments.

Caution should be exercised when interpreting many of the figures cited below. Many of the instruments are *not* in widespread use and much uncertainty remains regarding their effectiveness.

6.1 Emissions-Based Vehicle Registration Charge

Vehicle registration typically involves some sort of charge. The charge could be applied as a function of the vehicle's:

- total emissions (emissions per kilometre multiplied by the kilometres driven during the year);
- emissions per kilometre;
- distance travelled;
- fuel efficiency; or
- weight (a factor influencing fuel efficiency).

Clearly, the first option would provide the most direct incentive to reduce emissions. However, the other options would also encourage emission reductions by encouraging: the purchase of vehicles with good emissions performance or fuel efficiency; or reductions in vehicle use.

We did not identify any existing examples of car registration charges based on emissions performance or fuel efficiency. Denmark, however, does base its car registration charges on weight which is one determinant of fuel efficiency and, therefore, emissions (Nordic Council of Ministers, 1991). For vehicles weighing less 1,500 kgs, there is no charge. Vehicles over 1,500 kgs in weight are subject to charges of about CDN$780 (gasoline) and CDN$1,500 (diesel). There is a discount of CDN$2,500 for vehicles with catalytic converters.[1] No information is readily available on the effectiveness of these charges.

[1] Given the magnitude of the charges, it is likely that the "registration" charge is actually a one-time charge rather than an annual charge.

Truck registration charges in Canada are also commonly based on gross vehicle weight and, therefore, are indirectly linked to emissions. Exhibit 6.2 presents Quebec's truck registration charges. These figures are for 1986 and have undergone substantial revision since then. Further research to up-date these figures is required.

Exhibit 6.2
Truck Registration Charges in Quebec, 1986
(CDN dollars)

Class	Gross Vehicle Weight ('000 kg)					
	5	15	25	35	45	55
For-Hire	198	534	922	1,409	1,900	2,409
Private	178	484	836	1,279	1,725	2,188
Farm	74	265	471	696	930	1,171

Source: Nix (1986).

Note that the purpose of emissions-based registration charges for trucks would be to encourage the purchase of newer, cleaner trucks. There is not much potential for emissions-based charges to reduce the vehicle kilometres driven. Intermodal substitution is not likely to result from charges on the trucking industry (Jones, Nix and Schwier, 1990). Furthermore, Initiative S307 concluded that intermodal shifts would not significantly reduce NO_x or VOCs emissions (Canadian Council of Ministers of the Environment, 1994).

Two U.S. studies of hypothetical car registration charges estimated that hydrocarbon emissions from mobile sources would fall by about 4%. The hypothetical charge was based on the total annual emissions from the vehicle (emission factor multiplied by the vehicle miles travelled).

Recommendation: *High Priority*

Car registration charges based on emissions or fuel efficiency should be compared to vehicle

scrappage programs. Both provide incentives to purchase "cleaner" vehicles, although one is a charge (a "stick") while the other is a payment (a "carrot"). Registration charges may, however, be simpler to administer.

Truck registration charges may be useful to encourage faster adoption of cleaner truck engines that are now on the market. However, this potential instrument has not been assessed before.

6.2 Emissions-Based Vehicle Taxes

Emissions-based vehicle taxes would encourage the purchase of vehicles with higher emission performance, similar to the way fuel efficiency taxes encourage the purchase of vehicles with better gas mileage. Fuel efficiency taxes have been used by both the federal and provincial governments and the same may be true for emissions-based vehicle taxes. Further research is needed to verify this jurisdictional issue.

Similar to emissions-based vehicle registration charges, emissions-based vehicle taxes could be a function of:

- emissions per kilometre;
- distance travelled;
- fuel efficiency; or
- weight (a factor influencing fuel efficiency and, therefore, emissions).

The U.S. employs a slightly different type of emissions-based tax for heavy duty vehicles and engines. Under the U.S. Clean Air Act, manufacturers of heavy duty vehicles and engines that exceed emission standards are subject to financial penalties (Anderson, Hofmann and Rusin, 1991). Penalties increase with the degree of exceedance, thereby providing incentive to reduce emissions to as close to the standard as is economically justified.

Penalties have been collected since 1987. Between 1987 and 1989, total revenues from the penalties amounted to just under US$10 million. This is only a small fraction of the value of the vehicles and engines, so the incentive effects of the penalties are likely small.

Canada imports most of its heavy duty vehicles and engines and so a manufacturer's tax would, in effect, be an importer's tax. The purpose of such a tax would be to encourage truck buyers to purchase "cleaner" vehicles. New heavy duty engine technologies are now available on the market. Therefore, increasing the price of older engines may contribute to NO_x reduction targets.

Recommendation: *High Priority*

6.3 Vehicle Scrappage Programs

Also known as vehicle "buy-back" or retirement programs, these economic instruments offer a cash rebate to people scrapping old vehicles with poor emissions performance. Their purpose is to alter the composition of the vehicle fleet by encouraging substitution of cleaner, more fuel efficient vehicles for less fuel efficient vehicles with higher emissions.

Since 1976, Sweden has offered vehicle scrappage "bounties" to avoid abandoned car hulks and promote proper scrapping (Johansson, 1991; Nordic Council of Ministers, 1991; Opschoor and Vos, 1989). Until 1988, the bounty was about US$81 but did not provide sufficient incentive to be effective. In 1988, the bounty was raised to US$244. Further research is needed to determine if this increase in bounty affected the effectiveness of the instrument. The bounties are financed through a dedicated "deposit" on new vehicles. In 1988, the deposit was raised from US$49 to US$81.

In more recent years, several U.S. regions -- such as the South Coast Air Quality Management District (SCAQMD), the Philadelphia Air Basin and Chicago -- have developed vehicle scrappage programs. These programs have been induced in part by the 1990 amendments to the U.S. Clean Air Act. The amendments allow stationary sources in ozone non-attainment areas to obtain emission reduction credits by securing emission reductions from mobile sources.

Exhibits 6.3 and 6.4 summarize the environmental and cost effectiveness of four U.S. programs. The exhibits show clearly the need to evaluate vehicle scrappage programs in light of reductions of all pollutants, not just NO_x.

Exhibit 6.3
Environmental Effectiveness of U.S. Vehicle Scrappage Programs

Program	Average Emission Reductions (lbs/vehicle)		
	NO_x	HC	CO
ES/BAR (all model years)	97	900	3,696
SCAQMD (1972-1974 model years)	75	234	NA
CARB (1972-1974 model years)	90	279	1,140
Illinois (all model years)	68	421	NA

Source: B.C. Ministry of the Environment (1994).

Exhibit 6.4
Cost Effectiveness of U.S. Vehicle Scrappage Programs

Program	US$/Ton of NO_x	US$/Ton of HC	US$/Ton of NO_x + HC
ES/BAR (all model years)	$15,600	$1,680	$1,520
SCAQMD (1972-1974 model years)	$21,300	$6,800	$5,200
CARB (1972-1974 model years)	$18,000	$5,600	$4,400
Illinois (all model years)	$47,205	$7,579	$6,530

Source: B.C. Ministry of the Environment (1994).

It is worth noting that vehicle scrappage programs have received several recent acknowledgements as potential air quality programs.

- The Climate Change Task Group (1994) in their recent report on policy options included provincial vehicle scrappage programs. Such programs should target either pre-1975 or pre-1977 vehicles and could be administered in one of three ways:

  (i) automotive dealers screen trade-in vehicles, with rebate funding provided by government and automotive sector;

  (ii) automotive dealers and scrap yards would screen vehicles, thereby covering vehicle transactions undertaken both "privately" and through dealers; and

  (iii) government administers buy-back program in conjunction with an inspection and maintenance program.

- In June 1994, the B.C. government sponsored a workshop on vehicle scrappage program.

- In 1992, the Ontario Fair Tax Commission recommended a vehicle scrappage refund as a possible use of energy tax revenues (Ontario Fair Tax Commission, Environment and Taxation Working Group, 1992). However, such a refund system has not been implemented.

Recommendation: *High Priority*

There is growing evidence of the effectiveness of vehicle scrappage programs, and growing interest in their application in Canada.

6.4 Parking Pricing

Parking pricing refers to many different approaches to increasing the cost of parking to drivers, including:

- basing parking rates on vehicle occupancy;
- increasing fixed price parking charges; and
- eliminating subsidies for parking facilities.

Alternatively, parking pricing could also involve reducing charges at public transit park-and-ride lots. For example, the Ontario Fair Tax Commission (1992) examined the impact of exempting the Toronto Transit Commission's parking lots from a commercial concentration tax, but concluded that the impact on public transit use would be insignificant.

Parking price changes can result from government regulation of parking charges, changes to the tax system, or from the actions of individual employers.

The effectiveness of parking pricing differs between work-related trips and leisure trips. Exhibit 6.5 presents the findings of several U.S. studies of the impact of a US$2 increase in daily parking rates.

Exhibit 6.5
Environmental Effectiveness of Parking Pricing
(Effects of a US$2 increase in Daily Parking Charges)

	Reduction in...		
Type of Trip	**Vehicle Miles Travelled**	**Number of Trips**	**HC Emissions**
Work	3.0%	2.5%	2.8%
Non-Work	4.2%	5.4%	4.6%

Source: Apogee Research (1994c).

The same survey article concluded that the cost per ton of HC avoided ranged between $38,000 and $61,000.

A second article (Higgins, 1992) surveyed five U.S. studies of parking pricing and found:

- parking prices account for up to 80% of the variation in transportation mode employed by workers at six hospitals in San Francisco;
- eliminating free parking at one company in Los Angeles reduced the "drive-alone share" of employees from 42% to 8%; and

- employer parking prices can reduce solo driving among employees by 12% to 40%.

Recommendation: *High Priority*

The instrument appears to be environmentally effective. Further research is warranted.

6.5 Road Pricing

Road pricing can involve a variety of road user charges, including tolls for bridges, tunnels and roads and distance-based charges using Intelligent Vehicle Highway System (IVHS) technologies.

Road pricing is quite common in the U.S. as a means to finance transportation infrastructure and has been spreading to other countries. Singapore, the Netherlands, Norway, Sweden, Switzerland and the U.K. have initiated road pricing projects with both financing and environmental objectives (Beaudoin, 1992; Button, 1993). However, most projects are in the experimental stages.

Current fiscal pressures have increased the interest of several provincial governments in exploring road pricing mechanisms (Lafontaine, 1989; Bisson and Stevens, 1989). The GVRD's Transport 2021 includes recommendations to apply tolls on major bridges. A similar strategy may be suitable in the Montreal Urban Community where commuters from the mainland travel to the City of Montreal.

With significant progress in Intelligent Vehicle Highway Systems (IHVS), it is becoming more feasible to use road pricing to reduce emissions. Congestion pricing, one form of road pricing is frequently advocated as a means to reduce highway use, particularly during peak traffic hours and potentially during episodes of high ozone levels. Studies have evaluated the costs of transportation and estimated the "optimal" road prices that would internalize the full environmental costs (Apogee Research, 1994a; Button, 1993).

In the U.S., there have not been any applications of congestion pricing, largely due to equity issues and political acceptability. Some studies have estimated the impacts of hypothetical congestion pricing schemes. For example, two studies evaluated a congestion charge of US$0.15 per mile, corresponding to an average round-trip charge of roughly US$3 (Apogee Research, 1994c). The studies found potential reductions as follows:

Variable	Potential Reduction
Vehicle Miles Travelled	5%
Number of Trips	3%
Hydrocarbon Emissions	8%

In the context of Canadian NO_x/VOCs emissions, road pricing has been recommended by:

- City of Vancouver Task Force on Atmospheric Change (B.H. Levelton, 1993);
- Transport 2021 Medium-Range Plan for Greater Vancouver ($2 peak hour toll on bridges leading onto the Burrard Peninsula) (GVRD and B.C. Government, 1993b); and
- Transport 2021 Long-Range Plan for Greater Vancouver (GVRD and B.C. Government, 1993a).

Recommendation: High Priority

There are many outstanding implementation issues to assess. However, as a starting point the proposed study should focus on developing good estimates of the price elasticities of transportation demand (how vehicle miles travelled or vehicle trips might be affected by road prices). This would provide clear evidence of the value of road pricing.

6.6 Subsidies for Public Transit

Few public transit systems currently operate on a cost recovery basis. Nearly all receive subsidies from at least one level of government. For example, the Quebec provincial government provides subsidies worth 75% of capital costs (100% for rapid transit) and operating subsidies equal to 40% of passenger revenues (Alfa and Heads, 1986; Canadian Urban Transit Association, 1993).

Increasing such subsidies constitutes an economic instrument to reduce emissions from mobile sources. Transit systems could use subsidies to improve one or more of the characteristics that influence ridership:

- route structure;
- accessibility;
- network connectivity (transfers);
- frequency of service;
- fares;
- vehicle kilometres provided; and

- access and transfer time.

The response of ridership to various changes in these characteristics are well understood. For example, fare elasticities in Montreal have been estimated to be -0.16 to -0.14 for adults and -0.44 to -0.45 for school children (Canadian Urban Transit Association, 1985). This means that if greater subsidization allowed a 50% cut in fares, adult ridership would increase by about 8%. A decrease in vehicle emissions would then result from:

- reducing the number of vehicle miles travelled; and
- differences in the emission factors of private vehicles and public transit vehicles.

Montreal already has the highest annual per capita ridership -- 220 trips per capita per year -- and share of total trips -- 31% of all trips are on public transit -- in Canada (Canadian Urban Transit Association, 1993). Therefore, the elasticities may be higher in other cities. As a general rule of thumb, Canadian cities assume a fare elasticity of -0.30.

It is also worth noting that increased use of public transit decreases traffic congestion, which in turn encourages more traffic. This secondary effect may reduce the effectiveness of this economic instrument.

Recommendation: *Low Priority*

Given the many factors influencing ridership and the many uses to which funds could be used, increased subsidies to public transit must be evaluated within a comprehensive review of public transit systems. Such a review may be outside the scope of the proposed study.

The current fiscal climate also suggests that this economic instrument may not be worth detailed investigation.

6.7 Incentives for Buyers of Vehicles Running on Alternative Fuels

This economic instrument involves tax credits for expenditures on vehicles that operate on electricity, natural gas and other "clean" fuels. The tax incentives could be offered in the form of exemptions from federal and/or provincial sales tax or write-offs on income tax.

Such tax incentives are currently available in California (Borg, 1991). Income tax bills can be reduced by up to US$1,000 for purchasing an eligible car and US$3,500 for purchasing a van or small truck. The California Energy Commission also offers a US$1,500 subsidy for methanol-powered "flexible fuel vehicles" (FFVs) manufactured by General Motors and Ford. Finally, major gas companies in the state offer grants of $1,250 plus up to 50% of conversion costs for any

customer that converts their cars to run on natural gas.

The impacts of fuel substitution on air emissions are not well understood. For example, switching to electricity may not reduce total emissions if electricity is generated through coal-fired generating stations. Furthermore, alternative fuels may emit pollutants different from those emitted by using conventional fuels. More work on the "life-cycle" implications of fuel substitution is needed.

We also found little information on the cost effectiveness of such incentives. However, in 1991, the California Energy Commission's program helped sell 250 FFVs. Expected sales in 1992 were 2,500 vehicles (Borg, 1991).

Recommendation: Moderate Priority

These economic instruments do exist in California. Therefore, further research efforts could reveal the potential impacts of the instruments. However, further research should adopt a "life-cycle" approach to assessing their environmental effectiveness.

6.8 Fuel Efficiency Taxes on New Vehicles

So-called "gas guzzler" taxes are common in Canada and other countries, including the U.S. Such taxes already exist in at least several provinces. A federal excise tax also exists on vehicles (based on weight) and car air conditioners.[2] Exhibit 6.6 summarizes the fuel efficiency taxes in British Columbia and Ontario.

[2] Between 1974 and 1978, the federal government also had energy efficiency excise taxes on privately-owned aircraft, large power boats and high-powered motorcycles.

Exhibit 6.6
Examples of Provincial "Gas Guzzler" Taxes

British Columbia (effective 1980-1983)	
Transport Canada Fuel Consumption Ratings (litre/100 km)	*Social Service Tax Rate*
8.5 or less	2%
8.5 - 13.0	4%
13.0 or greater	6%
Ontario (levied in 1989)	
Highway Fuel Consumption Ratings (litre/100 km)	*Tax* ($/Car)
9.5 - 12.0	$600
12.1 - 15.0	$1,200
15.1 - 18.0	$2,200
> 18.0	$3,500

Source: Stone (1990).

We are unaware of any study of the impact of Canadian "gas guzzler" taxes on vehicle purchasing patterns.

Note that "gas guzzler" taxes may influence the choice of vehicle, but do not directly relate to the amount of fuel consumed and consequently the emissions generated. Once the vehicle is bought, the taxes provide no incentive to reduce vehicle miles travelled. Furthermore, "gas guzzler" taxes, such as the federal excise tax, are often related to the weight of the vehicle, rather than its fuel efficiency *per se*.

Recommendation: *Moderate Priority*

6.9 Government Procurement

Governments operate substantial vehicle fleets. This suggests that government procurement could be used to develop markets for innovative vehicles and fuels.

Government procurement may be useful to stimulate markets for vehicles that use alternative fuels. Alternatively, favourable procurement policies for the alternative fuels themselves (e.g. ethanol-blended gasoline) may also have some potential. Evaluating this potential will involve detailed knowledge of the availability of and constraints to alternative vehicles and fuels.

Environment Canada's Office of Environmental Stewardship is beginning a study on the costs and benefits of "greening" government procurement and other activities. This study will undoubtedly examine the potential impacts of "greening" government fleets. Its completion date is end of March.

Note that the developers of the GVRD vehicle fleet program concluded that the use of alternative fuels for vehicle fleets was not necessary to achieve emission reduction goals (B.H. Levelton, 1993). Instead, driver education, regular inspection and maintenance, and fuel efficient vehicles are recommended.

Recommendation: *Moderate Priority*

6.10 Reduction of Subsidies for Suburban Development

Governments provide significant subsidies for infrastructure to serve new suburban developments or "urban sprawl." Subsidized infrastructure includes roads, water treatment plants and sewer systems. While these subsidies offer other benefits, they can encourage suburban sprawl. This results in higher vehicle miles travelled and, consequently, higher emissions from mobile sources.

Reducing these subsidies -- potentially resulting in better cost recovery mechanisms -- may encourage more concentrated cities that facilitate walking, bicycling and economically viable public transit systems. Therefore, reduction of infrastructure subsidies can be considered an economic instrument for reducing emissions.

We found no studies of the environmental or cost effectiveness of this economic instrument. The B.C. Round Table on the Environment and Economy was planning a study of the environmental impacts of subsidizing suburban development. However, the Round Table was disbanded in June, 1994. We do not know if any other group will conduct the study.

Since the impacts occur only in the medium- to long-term, any estimates are likely to have a high degree of uncertainty attached to them.

Recommendation: *Low Priority*

Research efforts spent on evaluating the impact subsidies for suburban development on emissions are unlikely to have an immediate impact on policy decisions. Furthermore, creating more concentrated cities that facilitate walking, cycling and shorter vehicle trips must eventually be assessed within an urban planning context.

Nonetheless, identifying the issue may help raise the issue at the policy level.

6.11 Incentives for New Vehicle Technologies

Large vehicle manufacturers operate on-going research programs into new vehicle technologies, most of it outside Canada. Such research activities is unlikely to be affected by any new government incentives.

Incentives for vehicles using alternative fuels, however, may be more useful. There remain many outstanding issues regarding even the environmental effectiveness of alternative fuels (Concord, 1991).

Recommendation: *Low Priority*

The federal and provincial governments already fund some research and demonstration projects into such vehicles. Assessing the adequateness of this funding and the potential effects of increased funding could be included in a study of economic instruments for NO_x emissions from mobile sources. Given the current fiscal climate, this economic instrument may not warrant much attention.

6.12 Enforcement Incentives for Inspection and Maintenance Programs

Inspection and maintenance programs often impose mandatory repairs for vehicles that fail emissions tests. However, to avoid imposing financial hardships, the repairs are usually mandatory only if their cost does not exceed a specified level. For example, Massachusetts places a cap on repair costs of $100 or 10% of the value of the car, whichever is less (National Economic Research Associates, 1990).

Fees could be charged for emissions beyond the standard, giving vehicle owners the option of paying the emissions charge or repairing the vehicle. Alternatively, there could be a fine charged based on the degree to which the vehicle exceeds the emission standards.

No analyses of these economic instruments was found.

Recommendation: *Moderate Priority*

Several provinces are currently developing inspection and maintenance programs. An evaluation of enforcement incentives for I&M programs may be useful to these provinces.

However, detailed evaluations of the feasibility and desirability of enforcement incentives will still need to be conducted within a comprehensive study of I&M programs. Enforcement incentives are just one set of design options.

6.13 Incentives for Employer Transportation Management Programs

Employer transportation management programs can include numerous initiatives to reduce air emissions, such as:

- purchasing vans or high occupancy cars for pooling;
- subsidizing public transit passes purchased by employees; and
- installing racks and showers for cyclists.

Tax write-offs and/or direct support could be provided to employers who implement such initiatives.

Incentives for employer transportation management programs have been suggested in several recent studies (B.H. Levelton, 1992; Concord, 1991). However, we identified no existing incentive programs or evaluations of their effectiveness.

Note that the impact of *incentives* for employer transportation management programs would be only a fraction of the predicted reductions from the programs themselves. The GVRD Air Quality Management Plan estimated emission reductions of 3% to 5% for employer transportation management programs. However, several U.S. studies found that these programs reduce hydrocarbon emissions by less than 1% (Apogee Research, 1994c).

Recommendation: *Low Priority*

Incentives for employer transportation management programs are unlikely to have a significant impact on emissions.

6.14 Fuel Taxes

Fuel taxes are in widespread use for energy conservation, environmental purposes and, most commonly, revenue generation. Exhibit 6.7 lists the fuel taxes imposed by the federal and Quebec governments.

Taxes on leaded fuels are perhaps the best example of fuel taxes for environmental purposes. "Energy" taxes and carbon taxes have received significant attention in recent years as instruments to reduce greenhouse gas emissions.

Exhibit 6.7
Fuel Taxes as of January 1, 1992
(CDN$/litre)

Fuel Type	Federal Taxes	Quebec Provincial Taxes
Unleaded Gasoline	0.085	0.145
Diesel	0.040	0.126
Aviation/Turbo Diesel	0.095	0.030
Locomotive Diesel	0.040	0.030
Marine Off-Shore	0.040	Exempt
Coastal	0.040	Exempt

Source: Transportation Association of Canada.

Fuel taxes could serve either to reduce the consumption of fuels (and therefore emissions) or to finance emission reduction programs. To date, taxes levied on fuels for environmental purposes have been small relative to fuel prices. Tax revenues have also not typically been dedicated to environmental protection activities, although some notable exceptions do exist such as GVRD's tax on gasoline.

Recommendation: *Low Priority*

Given the large number of recent studies of fuel taxes, we do not believe it is worthwhile devoting the resources of the proposed study to assessing fuel taxes. There is also significant political opposition to (at least) carbon taxes.

However, if there are clear problems in financing specific emission reduction programs, fuel taxes could be assessed as a financing mechanism.

6.15 Intra- and Inter-Company Averaging of Vehicle Emission Standards

Vehicle emission standards are generally uniform; that is, each vehicle in a specified category must meet the same emission standard. This instrument would allow manufacturers to achieve an average emission standard across all its vehicles. For example, the manufacturer could achieve a standard of 1 g/mile by building one car that emits 2 g/mile and two cars that emit 0.5 g/mile.

Alternatively, inter-company trading could be allowed. Similar to intra-company averaging, *inter*-company averaging allows manufacturers to build some vehicles that exceed the vehicle emission standard if other vehicles built achieve a proportionally more stringent standard. In this case, averages can be calculated across two or more manufacturers.

Currently, intra-company averaging is allowed for complying with U.S. (and, apparently, Canadian) fuel efficiency standards (National Economic Research Associates, 1990).

The primary purpose of averaging emission standards is to reduce the costs of complying with the standard. Averaging would not necessarily produce emission reductions. Indeed, emissions could actually increase. Since individual vehicles vary in their emission performance, manufacturers must aim lower than the standards. Averaging may allow manufacturers to forego this safety margin, since variations are allowed. To overcome this problem, National Economic Research Associates (1990) suggests setting lower standards if averaging is allowed.

In addition to poor environmental effectiveness, there are several other potential problems with averaging. First, vehicle markets are North American in scope. Allowing averaging in Canada may not have any effect due to the high levels of trade in the motor vehicle industry.

Second, intra-company averaging is currently being challenged under the General Agreement on Tariffs and Trade (GATT) (Apogee Research, 1994b). The U.S. levies Corporate Average Fuel Efficiency taxes on the average fuel efficiency of each company's vehicles. The European Community alleges that intra-company averaging favours full-line car manufacturers (based in the U.S.) over the limited-line, high performance or luxury companies (based largely in Europe). The GATT Dispute Panel has yet to rule on the case.

Finally, averaging may make it more complicated and costly to operate vehicle inspection and maintenance programs. Detecting violations may be more difficult if emissions performance is allowed to vary across vehicles.

Recommendation: *Low Priority*

7. Implementation Issues

In this section of the report, we identify several issues related to the implementation of the economic instruments and offer several recommendations.

Jurisdictional Issues

All levels of government -- federal, provincial and municipal -- have at their disposal economic instruments to reduce NO_x emissions from mobile sources. Exhibit 7.1 indicates potential level(s) of government to implement each of the economic instruments.

Since many of the instruments are adjuncts to other programs, it is clear which level of government would implement them. For example:

- emissions-based vehicle registration charges are linked to vehicle registration, a provincial program;
- road pricing is linked to provision of road services, a provincial and, perhaps, municipal responsibility;
- parking pricing is linked to provision of parking services, as regulated by municipalities; and
- non-conformance penalties for vehicle manufacturers and corporate averaging of emission standards both complement federal vehicle emission standards.

However, many of the instruments could overlap two or more jurisdictions. Jurisdictional authority is a very complex issue and must be assessed in detail for each, individual instrument. The exhibit presents only our preliminary thoughts and must be verified by legal experts.

Note that only one of the instruments ranked "high priority" are likely to be implemented by the federal government. However, the federal government could probably implement many of the other instruments.

Enabling Legislation

Many of the instruments are already in place to some extent, including fuel taxes, energy efficiency taxes, government procurement, incentives for new vehicle technologies and subsidies for public transit. These instruments would not likely require extensive or any legislative changes.

The use of emissions-based vehicle registration charges may be constrained by legislation that limits

Exhibit 7.1
Potential Level of Government for Implementing Economic Instruments for NO_x Emissions from On-Road Sources

	Likely Level of Implementation		
	Federal	**Provincial**	**Municipal**
High Priority			
Emissions-Based Vehicle Registration Charges		X	
Emissions-Based Vehicle Taxes	X	X	
Vehicle Scrappage Programs		X	
Road Pricing		X	
Parking Pricing			X
Moderate Priority			
Fuel Efficiency Taxes on Vehicles	X	X	
Government Procurement	X	X	X
Incentives for Buyers of Vehicles Running on Alternative Fuels	X	X	
Reduction of Subsidies for Suburban Development	X	X	X
Low Priority			
Incentives for New Vehicle Technologies	X	X	
Enforcement Incentives for I&M Programs		X	
Incentives for Employer Transportation Management Programs	X	X	X
Fuel Taxes	X	X	
Subsidies for Public Transit	X	X	X
Intra- and Inter-Company Averaging of Vehicle Emission Standards	X		

registration charges to cost recovery. Implementation of parking pricing and road pricing may also be constrained by current legislation.

Dispersion Modelling

We recommend that dispersion modelling *not* be required in the proposed study. There are two reasons for this recommendation.

First, reductions in emissions of NO_x and VOCs will result from the interactions of many different initiatives, economic instruments and others. Dispersion modelling should be undertaken for a package of initiatives, not for selected economic instruments alone.

Second, there are many questions regarding the feasibility of these economic instruments. These questions should be answered before expending the resources on detailed analysis of the potential impacts of the instruments.

Instead, we suggest that, for the purposes of this study, "environmental effectiveness" be defined as the ability to achieve specified emission reductions or to shift emissions away from peak times and/or high-emission areas.

Appendix A

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Appendix A

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Appendix B

Descriptions of Transportation Control Measures

Appendix B

Appendix B provides descriptions of the TCMs evaluated in:

- Apogee (1994). "Costs and Effectiveness of Transportation Control Measures: A Review and Analysis of the Literature." Prepared for the Clean Air Project, National Association of Regional Councils.

Although the report deals with TCMs in the U.S., the descriptions are generally transferable to the Quebec context.

Employer Trip Reduction (ETR)

An area ETR program involves a regulation requiring employers, usually those above a certain size, to develop and carry out plans which encourage workers to switch from single-occupancy vehicles. Typical features of an employer's ETR plan include carpool information and matching services, preferential parking for HOV users, bike racks or showers, moderate subsidies for vanpools or transit, and guaranteed rides home for those who work late and miss carpools or transit service. Although parking charges can also be part of ETR plans, few employers choose to include this strategy. In this analysis, an ETR with a significant parking-charge component is considered a parking charge, not as an ETR. Employers are required to encourage workers to change their commuting practices, but workers are not required to do anything they do not want to do. Regulation XV of the South Coast Air Quality Management District in California is probably the best known example of an ETR program and is certainly the most closely studied.

Area-Wide Ridesharing

An area-wide ridesharing program provides carpool matching and information services. It may also involve promotional activities aimed at encouraging carpooling. Area-wide ridesharing may be operated directly by local government or by a non-profit contractor. In the latter case, area-wide ridesharing activities receive financial support from local government or from businesses that wish either to encourage carpooling or to ensure that ridesharing is an option available to their workers. Commuter Transportation Services in Southern California is a well-known area-wide ridesharing program, and similar programs have been tried in many areas of the U.S. These are strictly exhortation-and-information efforts.

Transit Improvements

Transit improvements are the oldest form of TCM. Ever since government financial support of mass transit became widespread in the fifties and sixties, expenditures on transit have been justified, in large part, on the grounds that high-quality mass transit services will draw people away from SOV use and that financial subsidies are needed to help offset direct and indirect subsidies to auto travel. Recent history indicates that much new transit ridership growth generate by investment comes not from converted SOVs

but from carpools, vanpools, and other transit modes (such as existing bus lines in the case of new rail service). As a transportation control measure, transit improvements seek to offer a desirable alternative to the auto. Transit improvements are carried out by transit authorities that are agencies of local governments, often with federal financial support. In fact, transit is not a single mode; it includes buses, light rail, heavy rail, commuter rail, etc. The relevance of each type varies widely depending on past investment, population and travel density, and other factors. This TCM includes several types of improvements ranging from new rail transit lines and expanded bus service to reduced transit fares. The cost-effectiveness estimates offered in Apogee Research (1994) are based on major rail transit improvements which are, generally, the most costly types of transit projects. This is because much of the literature on this measure tends to focus on various rail transit investments.

HOV Lanes

In the same spirit as a transit improvement, a high occupancy vehicle (HOV) lane is a facility offered to the motorist in the hope of drawing people away from single occupancy vehicle use. A HOV lane is a highway lane reserved for the use of buses and carpools above a certain size; for example, many HOV plans require carpools to have at least three members. The attraction of HOV lanes is that vehicles can move at faster speeds while SOV users are trapped in stop-and-go conditions in the highway's main lanes during peak periods. Almost invariably, HOV lanes must be provided through construction of new capacity, since there is usually great public resistance to converting existing lanes to HOV-only status. HOV lanes have been part of the urban transportation planner's toolbox for at least 30 years.

Park-and-Ride Lots

A park-and-ride lot is simply a parking lot, usually located for convenient access to a transit station or a HOV lane. Like a HOV lane, a park-and-ride lot is offered to the public to help induce SOV commuters to switch to transit or to carpools. Park-and-ride stands out among TCMs in that it makes sense primarily as a supplementary inducement to transit service or HOV lanes.

Bicycle and Pedestrian Facilities

Bicycle and pedestrian facilities comprise one of the less sharply defined TCMs chosen for analysis. Generally, the category refers to the provision of paths or other facilities which pedestrians and cyclists can use without interference from auto traffic. It may also include the provision of bicycle storage facilities and showers at or near work places. Finally, this category includes projects which improve safety for cyclists and pedestrians -- creating a "friendly" environment. Provision of paths or reserved rights-of-way requires both regulatory and investment actions, usually by local government. Extensive bicycle and pedestrian facilities of the kind envisioned in some of the literature are not common.

Parking Pricing

Most people who drive to work receive parking from their employers at no charge. One version of a parking pricing TCM would be to charge employees the full market price of their parking. The market price of parking is high -- especially in denser urban regions; some workers would change their commuting arrangements if charged the full market price of parking. Although employers could reduce their out-of-pocket costs if they stopped paying for workers' parking, most are reluctant to do so. Provision of parking is perceived, by firms and workers alike, as a significant component of employee pay and benefits (a tax-free benefit to employees).

A less stringent variant of full market pricing is the so-called "cash-out" scheme -- the firm pays employees the cash value of a parking space and the workers decide whether to use the money to retain their parking places or to change their commuting behaviour and use the money in some other way. In this way, a worker's commuting decision is influenced by the price of parking but the worker is not confronted with an additional charge. Another version of the "cash-out" scheme is the transportation voucher -- workers receive vouchers for the value of the parking payment, but the vouchers can be used only for commuting expenses. The U.S. Energy Policy Act revisions of 1992 include similar exceptions for employer transit subsidies. President Clinton's Climate Change Action Plan of 1993 proposes that certain employers be required to offer their employees either subsidized parking or the value of that parking if they choose not to accept the subsidy.

Congestion Pricing

Commonly used in public utility and air travel pricing (referred to as "peak-load" pricing), congestion pricing is only rarely applied to road pricing and has never been implemented on a large scale in North America. However, it is the measure many planners and economists recommend to encourage mode switching, to deflect travel demand away from peak periods, and to eliminate some trips altogether. The concept is simple: at hours of peak demand charges are assessed which are high enough to reduce highway use and thus congestion. The charge can be in the form of tolls on some or all of a region's freeways and major arterials, or in the form of a cordon charge -- a toll for crossing a line around a major urban area or set of activity centers. Several cities already have peak/off-peak pricing differentials on bridges.

The distinctive feature of congestion pricing is that charges vary with the level of demand or some close proxy, such as time of day. When demand falls below a certain threshold level and there is no congestion, the price drops to zero. To be effective, a congestion charge must be high enough to prevent a significant number of people from using highways at the time when they would prefer to travel. The San Francisco Bay Area recently received one of five congestion pricing demonstration grants authorized by ISTEA (four have yet to be awarded).

Compressed Work Week

In a compressed work week plan, work trips are reduced by extending the hours worked per day and reducing the number of days worked. The most common versions are known as the 4/40 and the 9/80. In the former, people work four ten-hour days in a week; in the latter, 80 hours are spread over nine days in a two-week period. The 4/40 eliminates one round-trip a week; the 9/80 eliminates one every two weeks. However, these reductions can be partially or fully negated by additional travel on the days off. Most current compressed work week proposals exhort, rather than compel, employers to adopt such practices. Any decision on whether to comply rests with employers.

Telecommuting

Telecommuting eliminates work trips by allowing employees to work at home some of the time. As with compressed work weeks, the decision on whether to implement such a measure is up to businesses and, perhaps, their employees. Telecommuting is most feasible for workers who provide information and/or analysis and who can carry out part of their responsibilities without immediate support from their colleagues. In general, it is anticipated that an employee would work at home one or two days a week and at the office the rest of the week. In many instances, the home workplace would require a full

complement of electronic office tools: computer, modem, and fax. Under one version of telecommuting, employees would work at centers near their homes where all such facilities would be available. Such a scheme shortens work trips but does not eliminate them, making it less effective in terms of emissions reduction.

Land Use Planning

The TCM aspect of land use planning involves designing new developments so that communities generate less travel in general and less travel by auto specifically. In such communities, jobs and housing would be located closer together and service and retail activities would be grouped close to dwellings and to workplaces. Residents would take fewer and shorter non-work trips and trips from the workplace to service and retail functions, and more trips could be taken on foot, by bicycle or by transit. Final decisions on implementing such schemes would rest with a variety of government agencies and private firms. Central actors would be local zoning boards and private developers. How well planning works in practice to reduce auto use would depend on the decisions of people and firms to locate in the new development and use it as intended. This set of measures operates over a different time frame than the others.

Signal Timing

Traffic signal timing can be improved to enhance significantly the flow of vehicles on arterial networks. This would likely include an initial analysis and re-setting of timing in a region plus on-going monitoring and adjustment of the system. The impact on emissions stems from auto travel in less congested conditions, not from less auto travel. Local traffic authorities would be responsible for such measures.

Incident Management

Incident management programs involve mitigation and speedy removal of traffic blockages caused by accidents and breakdowns. Such efforts depend on information and communications improvements for timely identification of trouble and availability of crews and equipment for rapid response. Like signal timing, the objective is to increase the physical efficiency of existing facilities by improving flow and not to dissuade people from using them.

Emissions/VMT Tax

This measure encompasses a broad set of policies. An emissions-based fee would replace or supplement existing registration fees with those charged on the basis of emissions. A province could charge a vehicle registration charge on the basis either of emissions per kilometre, or a combination of emissions per kilometre and total miles driven. A finely-calibrated system might charge in direct proportion to emissions; a rougher one might group cars into broad categories. One option would normalize fees across age groups; another would not, on the theory that emissions are emissions, no matter how old the car. In the latter case, an emissions fee would encourage the retirement of older cars with less efficient emissions systems. Depending on their level, the fees can also motivate repair in cases where repair costs are less than the fee for the higher emissions level. Finally, adding a VMT component can encourage both repair and decreased VMT.

Buy-Backs of Older Cars

This measure involves paying owners of old cars to scrap their vehicles. Since, on average, older cars are far worse polluters than newer cars, junking them will reduce total emissions. Older cars often generate greater emissions because they have less effective emissions controls systems which also may have deteriorated over time. However, the relative effectiveness of such a program will decrease over time as normal scrappage takes the worst polluters off the road. By far the largest effort of this kind to date has been UNOCAL's buy-back program in southern California. Of its own volition, and using its own money, UNOCAL bought and scrapped pre-1971 cars. Institutions which might run buy-back programs include private firms interested in reducing mobile emissions, such as utilities or oil companies, and government agencies which could either offer their own scrappage programs or induce private firms to do so. In the U.S., some private firms have an interest in reducing mobile source emissions because of lessened pressure for stationary source emission reductions or because of credits from air quality regulatory agencies. As with most TCMs, the likely effectiveness and ease of implementation will vary by community circumstances (their local fleet mix, for example).