Typology of Approaches to Sustainable Road Transportation

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1.0 Introduction

There are three essential elements of effective sustainable development programs. They must meet environmental needs, they should be economically viable and they should be socio-politically acceptable. In the transportation sector sustainability is a concern due to the significance of the sector’s contribution to greenhouse gas (GHG) emissions.

Environment Canada estimates\(^1\) that there were 15,700,000 tonnes of GHG emissions released in Manitoba in 2001. The transportation sector emitted 7,020,000 tonnes or 45% of the total. The largest contributor was 4,620,000 tonnes emitted from road transportation. In view of the importance of road transportation to emissions production this research document outlines the various approaches that have been adopted for their reduction.

Methods to ameliorate the effect of transportation on GHG emissions continue to evolve. This typology is designed to provide an overview of the many approaches that have been adopted in Canada and elsewhere. They are grouped into seven categories:

- Regulatory Approaches,
- Technology Improvements,
- Pricing Changes,
- Traffic Reduction Measures,
- Public Education Programs,
- Improving Transportation Resource Usage, and
- Demonstration and Rewards Programs.

2.0 Regulatory Approaches

Regulatory approaches focus specifically on setting parameters that restrict the amount of emissions created through vehicle operation. These are amongst the oldest of techniques used to reduce vehicle pollution.

2.1 Passenger Vehicles and Light Duty Truck Emissions Standards

Passenger cars, vans, sport utility vehicles, and light trucks have gone through a series of ever-stricter emission standards since the 1970’s. In the United States, these were known as Tier 0 and Tier 1 standards. In 2004, these vehicles were required to comply with Tier 2 standards. Coupled with Tier 2, is a requirement placed on refiners to reduce the sulfur contents of their fuel. Tier 2 standards are also being followed in Canada and are amongst the most stringent in the world.
Tier 0 started in the 1970’s and continued through to 1990. The focus was on nitrogen oxide emissions (NOx,) with carbon monoxide (CO) and particulate matter (PM) also being regulated. To meet these requirements manufacturers adopted approaches such as positive crankcase ventilation systems, gasoline purge canisters, catalytic converters (1-way in 1975 and 3-way in 1981), exhaust gas recirculation (EGR) and the use of unleaded gasoline. Tier 0 also popularized electronic engine management systems and on board diagnostic systems (OBD), that indicated fault in critical engine and pollution control systems (OBD1). During this time period, regulations on releases of NOx were decreased by about 67% from about 3 grams per mile to 1 gram per mile.\(^2\) Light duty vehicles (vans, sport utility vehicles, and light trucks) were allowed slightly higher emissions due to their general commercial use. Larger trucks with gross vehicle weights more than 6,500 pounds (2,950 kg) had more liberal treatment, with allowable emissions approximately 50% higher than light trucks.

Tier 1 standards developed from the 1990 Clean Air Act in the United States. These further reduced NOx, and added regulation of hydrocarbon emissions. Coming into effect in 1994, NOx emissions were reduced a further 60% to 0.4 grams per mile, with cars and light trucks set at the same standard. CO emissions remained at 3.4 grams per mile, and PM was reduced from 0.2 grams per mile to 0.08 grams per mile. Non-methane hydrocarbons (NMHC) were regulated at 0.25 grams per mile compared to 0.34 grams per mile. Onboard diagnostics were further improved with the adoption of OBD2 in the mid 1990’s. OBD2 added further monitoring capability including engine misfire monitoring, catalytic converter efficiency, exhaust gas recirculation flow and purge canister monitoring. Again, the heaviest vehicles in this category were treated much less rigorously with allowable emissions only reduced 10%.

Focusing on NOx emissions, Tier 2 standards came into effect for the 2004 model year\(^3\) with an approximate three-year phase in period. At the end of the phase in, NOx emissions will be reduced to 0.07 grams per mile for all passenger cars, vans, and light duty trucks (less than 6,501 pounds GVW (2950 kg GVW)). Heavier duty vehicles in this category (now officially defined as medium duty vehicles) are required to make substantial reductions in emissions, however they have retained a more favourable treatment compared to light duty vehicles until 2007. They are to meet the same targets as light duty vehicles by 2009. Coupled with the Tier 2 requirement is regulations that refiners produce sulfur-reduced gasoline from a corporate average of 300 ppm to 30 ppm by 2007.

### 2.2 Heavy Duty Highway Truck Emissions Standards

The United States Environmental Protection Agency (EPA) has also taken a lead role in regulating emissions for heavy-duty diesel engines, using a multi-year systems oriented approach. The systems based view involves the integration of cleaner diesel fuels as an additional enabler to cleaner diesel engines. Canadian standards have followed the U.S. lead, given the preponderance of diesel engine and highway tractor manufacturing in the United States and the increasing integration of the two economies.
The initial changes in emissions for highway diesel engines began in the early 1990’s resulting in a capping by 1998 of NOx and PM emissions at 38% and 17%, respectively, of the levels allowed in the late 1980’s. Diesel fuel was limited to having 500 parts per million (ppm) sulfur content, which enabled the use of exhaust catalyzers.

For model year 2004, additional limits were set for NOx, roughly decreasing NOx a further 50%. Limits were also set for NMHC. The 2004 regulations were in fact implemented in late 2002 after litigation between the diesel engine manufacturers and the EPA. Generally these were met in 2002 by incorporating technology similar to gasoline-powered vehicles, including variable valve timing, exhaust gas recirculation systems and exhaust catalyzers.4

The EPA has established new, more stringent standards for diesel emissions that take effect in 2007. As well, refiners will be required to produce ultra-low sulfur (15 ppm) diesel fuel starting in 2006. By mid 2006, 80% of the diesel fuel supplied will be low sulfur, rising to 100% in 2009.

For diesel engines, starting in 2007 with a 3 year phase in, engine emissions will be capped, with NOx set at 20% of the 2002 level, NHMC at 30% of the 2002 level, and PM at 10% of the 1998 level. Heavy-duty gasoline engines will be required to meet the same standards for 2007. Engine manufacturers will conduct early prototype testing of the technologies to meet these standards in 2005.5

2.3 Corporate Average Fuel Economy Regulation

Corporate Average Fuel Economy (CAFE) regulations started in the United States with the Energy Conservation Act of 1975. The Act mandated improvements in fuel economy for vehicles produced in the United States. Basically, the Act stipulated that the average fuel economy of a manufacturer’s output of passenger and light duty vehicles must meet a specific target. The target generally increased over time as shown below:

- Passenger Vehicles:
  - 1978: 18 miles per gallon (mpg)
  - 1979: 19 mpg
  - 1980: 20 mpg
  - 1981: 22 mpg
  - 1982: 24 mpg
  - 1983: 26 mpg
  - 1984: 27 mpg
  - 1985: 27.5 mpg
  - 1986-88: 26 mpg
  - 1989: 26.5 mpg
  - 1990-2004: 27.5 mpg
Light Trucks

- 1979: 2 wheel drive – 17.2 mpg
  4 wheel drive - 15.8 mpg
- 1980: 2 wheel drive – 16.0 mpg
  4 wheel drive - 14.0 mpg
- 1981: 2 wheel drive – 16.7 mpg
  4 wheel drive - 15.0 mpg
- 1982: 2 wheel drive – 18.0 mpg
  4 wheel drive - 16.0 mpg
- 1983: 2 wheel drive – 19.5 mpg
  4 wheel drive - 17.5 mpg
- 1984: 2 wheel drive – 20.3 mpg
  4 wheel drive - 18.5 mpg
- 1985: 2 wheel drive – 19.7 mpg
  4 wheel drive - 18.9 mpg
- 1986: 2 wheel drive – 20.5 mpg
  4 wheel drive - 19.5 mpg
- 1987-88: 2 wheel drive – 21.0 mpg
  4 wheel drive - 19.5 mpg
- 1989: 2 wheel drive – 21.5 mpg
  4 wheel drive - 19.0 mpg
- 1990: 2 wheel drive – 20.5 mpg
  4 wheel drive - 19.0 mpg
- 1990: 2 wheel drive – 20.5 mpg
  4 wheel drive - 19.0 mpg
- 1991: 2 wheel drive – 20.7 mpg
  4 wheel drive - 19.1 mpg
- 1992: combined; 20.2 mpg
- 1993: combined; 20.4 mpg
- 1994: combined; 20.5 mpg
- 1995: combined; 20.6 mpg
- 1996-2004: combined; 20.7 mpg

When manufacturers exceed the CAFE standards fines are levied.

Canadian standards, known as company average fuel consumption (CAFC), are voluntary but have followed those of the United States.
3.0 Technological Improvement

Technological improvements include a variety of other activities including: the development of new fuels, better aerodynamics, lower rolling resistance tires and intelligent transportation systems.

3.1 Alternate Fuel Types

Shifting from gasoline and diesel powered vehicles to those that are more environmentally friendly has been increasing in the transportation sector. Amongst the fuels and power combinations of the future that have been tested are: ethanol/methanol blended gasoline, ethanol/methanol blended diesel, compressed natural gas, liquefied natural gas, liquefied propane gas, biodiesel, hydrogen fuel cell, hydrogen internal combustion engine and electric or electric hybrids.

The advantage of these technological changes is that they reduce emissions directly at the source, the burning of fuel as motive power. The chief disadvantages of these technologies include lack of fuelling infrastructure, vehicle service life concerns and limited operational range of some technologies such as battery powered electric vehicles.

Some examples where these new technologies are being used include:

- Liquefied propane gas taxis in numerous cities,
- Biodiesel buses in Brampton Ontario,
- Experimental hydrogen fuel cell buses in California,
- Ethanol blended gasoline in various U.S. states,
- Liquefied natural gas truck tractors operated by UPS, and
- Electric powered ground service vehicles used by American Airlines.

3.2 Improved Aerodynamics

Aerodynamic drag, or wind resistance accounts for a significant portion of truck energy losses at highway speeds. By reducing drag, GHG emissions are reduced.

Automobile engineering and design changes have resulted in substantial reductions in drag over the last 20 years, with typical coefficients of drag (Cd) dropping from .48 to .33. For transport trucks similar improvements have been made by using sloped hoods, roof fairings, cab extenders, side fairing and front bumper air dams. Trailer aerodynamics has been improved by minimizing the gap between the tractor and the trailer to reduce air turbulence and installing side skirts.
3.3 Lower Rolling Resistance Tires

Rolling resistance is an important factor in fuel economy and consequently vehicle emissions. Estimates of total fuel used to overcome rolling resistance of tires ranges from 4% to 7%. In order to reduce tire rolling resistance, automobile manufacturers have adopted non-aggressive tread patterns and relatively high tire pressures. At the limit this approach adversely affects handling and ride comfort of the vehicle. To counter these difficulties specific, low rolling resistance tires with different profiles are being introduced. An example of these new designs is the Goodyear E metric tire used on vehicles such as the Toyota Prius. The special design features allow these to operate at higher air pressures and maintain suitable ride comfort and handling characteristics.

Rolling resistance of tires account for almost 13% of truck energy use. Most trucks have two sets of wheels and tires at the end of an axle, which increases rolling resistance and weight. Replacing dual tires with single wide base tires lower the rolling resistance and aerodynamic drag. They are lighter than two standard tires and wheels, with the weight savings reducing fuel consumption. Estimates are that single wide tires can potentially improve fuel economy by 2-5%.

3.4 Intelligent Transportation Systems

Intelligent Transportation Systems (ITS) use information technology to improve the efficiency and performance of transportation systems. They require coordination between a variety of partners to be successful.

There are numerous types of ITSs, as discussed in the following sections.

3.4.1 Traveler Information Systems

Traveler information systems provide travelers with real-time transit and traffic information disseminated through: telephones, television monitors, radio, electronic signs, kiosks, personal computers, PDA’s, pagers and the Internet. From this information travelers can make better decisions about the most efficient and convenient mode of transport. Examples of the types of questions traveler information systems answer are: When is the next bus arriving? How many spaces are left at the park and ride? What is the actual travel time from A to B?

Traveler information systems can be broadly categorized into three different areas:

- **Pre-Trip Information Systems**

  These give travelers important information before they even start their trip. Traditionally automated telephone systems were used, but newer technology is
now using the Internet, kiosks and PDA’s. An example of information received through pre-trip information systems is transit routes, schedules and fares.

- **In-terminal and Wayside Information Systems**

In terminal and wayside information systems provide travelers with arrival and departure information, schedule up-dates and transfer information, all by means of electronic signs, kiosks, or television monitors.

- **In-vehicle Information Systems**

In-vehicle information systems supply information inside transit vehicles through small electronic displays and annunciators. They normally display where you are on the route and what the next stop is.\(^9\)

### 3.4.2 Transit Management Systems

Transit management systems can improve transit operations as well as increase safety and improve efficiency. They use advanced software and communications equipment to transfer data between transit management centres and transit vehicles. These systems can be used to confirm scheduling information, improve transfer coordination and reduce passengers wait times.\(^10\)

Some different types of transit management systems are:

- **Automatic Vehicle Location Systems**

Automatic vehicle location systems are computer-based vehicle tracking systems that monitor vehicle locations in real-time. This provides real-time input to traveler information systems, is able to locate vehicles during emergencies, and provides input to traffic signals for transit priority intersections.

- **Automated Passenger Counters**

These collect information relating passenger boardings and departures by time and location. This data is then used to plan, operate and schedule transit routes, as well as input information into the traveler information system.

- **Mobility Managers**

Mobility managers integrate and coordinate transportation services offered by multiple providers. It helps different transit and transportation authorities provide more coordinated service by reducing redundant billing and collection.\(^11\)
3.4.4 Traffic Signal Optimization

Traffic signal optimization programs have as an objective the optimization of route travel time on major traffic corridors. Using traffic flow data for specified time periods, traffic flow is optimized on the specific corridor, with stops and starts reduced. Generally there are two methods of optimization. Static systems use traffic count information and observation. Signals are optimized and remain on a fixed set of cycles for a time period. Dynamic systems adjust in a more active manner either through dynamic flow counting methods or through resetting signals from a central location.

Estimates of the savings from travel signal optimization typically suggest about a 10% reduction in travel times, a 10-15% decrease in stops and starts and a 5-10% reduction in fuel consumption, contributing to reduced GHG emissions.12,13

3.4.5 Smart Cards

A smart card is a plastic card about the size of a credit card, containing an embedded microprocessor chip that is used by transit providers. The benefits of smart card technology, to both the customer and the transit operator are:

- Convenience for the customer,
- Versatility of combining credit, debit, stored value cards into one platform,
- Lower operating costs due to reduced cash and coin handling, and
- Reduced maintenance since the card readers with contactless cards have no moving parts.14

By simplifying the transit company customer interface the smartcard increases demand for transit services thereby reducing emissions.

4.0 Pricing Changes

4.1 Road Pricing

Road pricing involves directly charging motorists for using a particular road or driving in a certain area. It is often viewed as a more efficient and equitable way to pay for road costs and as a method to encourage more efficient transportation.

There are two broad types of road pricing being used:

- Toll roads, and
- Congestion pricing.

Toll roads are the direct imposition of a fee for the use of the roadway. This may involve traditional toll plazas where road users pay a fee, or more modern technologies such as in
vehicle transponders that monitor vehicle location and bill the owner on a weekly, monthly or quarterly basis.

Congestion pricing is used as a demand management strategy to reduce traffic congestion. Typically it attempts to change driving patterns by charging time-variable tolls, which are higher during peak periods and lower or zero when roads are uncongested. The benefit of congestion pricing is a reduction in peak period traffic congestion, coupled with a shift of traffic to alternative modes such as ridesharing, public transit, cycling and walking. It also improves road safety, protects the environment and encourages more efficient land use. One of the main benefits is that individuals bear the costs they impose and therefore use road resources more efficiently. The disadvantage is it can just shift traffic to travel on unpriced routes.

Two examples of road pricing are toll road Highway 407, which crosses the Greater Toronto Area (GTA)\textsuperscript{15} and the implementation of the congestion charge zone in London, England.

- **Toronto**
  Highway 407, which runs across the top of the GTA, is an example of toll road pricing. The first phase of the highway, that opened the fall of 1997, is a multi-lane electronic highway running 108 kilometres. Average speeds on the 407 are double that of parallel highways which do not charge. Electronic transponder cards that are located in the individuals’ vehicle collect approximately 70\% of tolls. These automatically deduct charges from a prepaid account. The remaining 30\% use a license plate photography billing system, where the registered owner of the vehicle is mailed a bill for highway usage at the end of each month. The amount of the toll depends on the time of day, the vehicle class, distance traveled, and use of a transponder in your vehicle. For a basic passenger vehicle, peak rate charges are about 13.95 cents per kilometre with the off-peak rate set at 13.10 cents per kilometre. If you do not have a transponder there is an extra $3.35 video toll charge per trip.\textsuperscript{16}

- **London**
  In 2003 London introduced a congestion charge zone to reduce traffic congestion and pollution in a 22-square kilometre area of central London. The goal was to get 10-15\% of the individuals that drive into central London not to drive their vehicles and to take transit instead. At the date of inception no other city had attempted implementing charging on this large of a scale.

  Prior to the change, congestion in London’s city centre had been increasing at a rapid rate. Average speeds in central London were about 15 kilometres per hour, and as slow as 2 kilometres per hour in some areas.

  The daily congestion zone charge is 5 pounds, or approximately $12 Canadian, and is valid for entries and exits to the congestion zone all day. The zone is in effect from 7AM until 6:30PM on weekdays. Vehicles not paying the charge are
subject to an 80-pound fine. Certain vehicles are exempt from the charges, such as: taxis, public transport, emergency vehicles, vehicles used by the disabled, two-wheeled vehicles and alternatively fueled vehicles. In addition, residents living in the zone get a 90% discount if they purchase a weekly pass.

The congestion area is monitored by 688 closed-circuit TV cameras that track each vehicle that enters and exits. The video images are then matched against computer records as to who has paid.¹⁷

About half the money collected from the charge zone covers the costs of the operation, and the rest, an estimated $290 million, has been targeted for improvements to public transit.¹⁸

### 4.2 Taxes and Fees

The general objective of taxes and fees are to increase the cost of producing emissions.

Taxation typical takes the form of a levy per unit of fuel consumed. The objective being to increase the cost of fuel and thereby encourage less usage and lower emissions. Such taxes are not necessarily designed solely for emissions reduction and may have other purposes; such as to generate government revenue and infrastructure development.

Fuel taxes in a variety of countries in 2003 were as follows: ¹⁹

- **Unleaded gasoline**
  - Canada: Federal Excise tax: $Cdn .10 per litre plus provincial taxes of $Cdn .09 to $Cdn .1650 per litre.
  - United States: $US.184 per gallon plus state taxes of $US.008 to $US.2640 per gallon.
  - Australia: $AU.3814 per litre.
  - France: .6396 euro per litre.
  - Germany: .5627 euro per litre.
  - Sweden: 4.62 to 5.3 Swedish Kronar per litre.
  - Japan: 48.6 yen per litre.

- **Diesel Fuel**
  - Canada: Federal Excise tax: $Cdn .04 per litre plus provincial taxes of $Cdn .09 to $Cdn .1650 per litre.
  - United States: $US.2440 per gallon plus state taxes of $US of $US.1165 to $US.3090 per gallon.
  - Australia: $AU.3814 per litre.
  - France: .3913 euro per litre.
  - Germany: .3785 euro per litre.
  - Sweden: 3,121 to 3,663 Swedish Kronar per cubic metre.
  - Japan: 32.1 yen per litre.
Fees in selected countries are as follows:

- **Canada:**
  - Heavy vehicle fee of $30 to $120 per vehicle.
  - Vehicle Air Conditioning tax $100 per vehicle.
  - Ontario Gas Guzzler Rebate/Fee: Rebate of $Cdn 100 per vehicle for passenger and sport utility vehicles with fuel efficiency below 6 litres per 100 kilometres to a fee of $7,000 per vehicle for passenger and sport utility vehicles with a fuel efficiency above 18 litres per 100 kilometre

- **United States:**
  - Luxury Tax: 5% fee on price of passenger vehicle above $US 38,000. ($US 57,000 limit for electric passenger vehicles)
  - Federal Gas Guzzler Tax: Fee ranging from $US1,000 to $US7,700 based on fuel economy. ($US1,000 for 21.5 to 22.5 miles per gallon, $7,700 for less than 12.5 miles per gallon).

- **Japan:**
  - Automobile Acquisition Tax: 3% to 5% of the purchase price.

### 5.0 Traffic Reduction Measures

#### 5.1 Traffic Calming

According to the Transportation Association of Canada’s Canadian Guide to Neighbourhood Traffic Calming, “traffic calming is the combination of mainly physical measures that reduce the negative effects of motor vehicle use, alter driver behaviour and improve conditions for non-motorized street users.” The Institute of Transportation Engineers defines it as, “changes in street alignment, installation of barriers, and other physical measures to reduce traffic speeds and/or cut-through volumes, in the interest of street safety, livability, and other public purposes.”

Traffic calming, due to its effects on vehicle speeds reduces pollution. It also discourages vehicle usage in some situations.

Traffic calming measures are divided into two groups based on the main impact intended:

- Speed control measures and
- Volume control measures.

Speed control measures are mainly used to address speeding problems by changing vertical deflection and horizontal deflection. Volume control measures are primarily...
used to address cut-through traffic problems by blocking certain movements, thus diverting traffic onto streets more appropriate to handle it.

Vertical deflection measures consist of speed humps, speed tables (essentially longer humps), raised intersections, raised crosswalks and textured pavements. Horizontal deflection measures consist of traffic circles, roundabouts, chicanes and intersection realignments.

Volume control measures consist of road closures (full and partial), restrictions such as diagonal diverters, median barriers, forced turned islands and neck downs.

5.2 Access Control

Access control is aimed at discouraging vehicles from accessing central areas of a city by restricting and controlling access. It reduces the number of vehicles in the city centre to those strictly necessary, while promoting public transport as an alternative means of transport. Only authorized vehicles are allowed in, such as residents of the city centre and a select group of non-residents.

One of the best examples of access control is in Rome, Italy. Beginning in 1989 Rome placed restrictions on vehicles entering the historic city centre. Only residents and select non-residents such as doctors with offices in the area, artisans, etc. were allowed to enter. In 1994 the restrictions started to be more strictly enforced. By 1998 authorized non-residents were required to make annual payments to receive a permit to access the city centre. The payments were the equivalent of a 12-month public transit pass. In October 2001 an electronic access control system was implemented. It was able to recognize the vehicle at both the entrance and exit gates, and accept an electronic payment system. The results after one year of the electronic access control system operating in Rome were a 20% reduction of traffic flows and a 6% increase in public transport. This system is currently the largest urban access control system in operation worldwide.

Besides Rome, access control measures have been implemented throughout Europe in Prague, Florence, Geneva, Zurich, Paris, and Lyon and in Germany and the Netherlands. They have also been tried in some U.S. cities.22

6.0 Public Education Programs

6.1 Individualized Social Marketing Programs

Social marketing programs are generally designed to modify the behavior of individuals toward a socially desirable goal. Within the context of sustainable transportation the objective is to modify individual’s use of the automobile, shifting them to other modes such as public transit, walking, biking, carpooling etc. with a prime goal of reducing
emissions. The focus is encouraging a willing non-regulated change in individual behavior. A common name for these programs in a transportation context is “Travel Smart” programs.

Travel Smart programs involve a sequence of steps that may be piloted on a subset of a community and then expanded to full coverage. These are:

- Design of a screening survey,
- Implementing the survey by phone to all households in the target zone,
- Triaging the respondents into those households/individuals who:
  - Are not interested in changing their behavior.
  - Exhibit the desired behavior.
  - May be interested in changing their behavior, and
- Follow-up where needed.

For individuals the benefits of the altered behavior include:

- Reduction in the costs of vehicle ownership,
- Improved health,
- A sense contributing to an improvement in the environment, and
- Reduced stress on their commute to work.

For society as a whole the benefits include:

- Reduced emissions,
- Decreased demand for road infrastructure,
- Improved utilization of infrastructure in place for alternate modes,
- Fewer road accidents, and
- Reduced demand for energy.

An example of a successful program is the Travel Smart program in Perth, Australia. The program started in 1997 with a pilot test of 35,000 individuals. In 2000 it was expanded to the entire city of 650,000.

Some of the results of the Perth Travel Smart experience are:

- A decrease in automobile travel of 14%,
- An increase in public transit of 16%,
- An increase in cycling of 61%,
- An increase in walking of 35%, and
- An increase in carpooling of 9%.
6.2 Idle Reduction Programs

It is estimated that Canadians idle their vehicles an average of about 60 million minutes per day on average. If every light duty Canadian vehicle were idled by 5 minutes less per day on average 930 million litres of fuel would be saved yearly. The Canadian approach to the idling problem for light duty vehicles has generally been public education programs. An example of this is The City of Toronto’s “Turn It Off” project.

Additionally heavy-duty vehicles are often left to idle. For long haul freight trucks, traditional reasons for idling have been to provide heat or air conditioning, to keep the engine warm, or to generate electrical power for in-truck equipment.

There are several solutions available to remedy the problem of truck idling. Auxiliary power units are mounted externally on the truck cab and provide power when the main engine is shut off. Automatic engine idle systems start and stop the truck engine automatically to maintain a specified cab temperature or minimum battery charge. Another option is truck stop electrification, where trucks get electrical power from an external source and shut off their engine.

Starting in 1984, U.S. based Southeastern Freight Lines, Inc. was one of the first companies to use idle time limits. Winnipeg based Bison Transport has installed sleeper berth heaters in all of their trucks, which reduces GHG emissions as a result of engine idling.

From a regulatory perspective many states and cities have passed laws to limit the amount of vehicle idling, particularly for commercial vehicles. In Canada it has been determined that regulations are less effective than public education campaigns in reducing idling, consequently education has been the approach used.

6.3 Reducing Highway Speed

Reducing highway speeds from present levels to the former 90 kilometre per hour level, according to research conducted by the Environmental Protection Agency in 1996 would reduce carbon monoxide emissions by 61%, NOx emissions by 10% and emission of volatile organic compounds by 36%.

In addition to reducing emissions, lowered speeds have the effect of reducing total fuel consumption, as aerodynamic drag is less at lower speeds, thus requiring less motive energy.

One approach to containing highway speeds is implementing a speed management policy for commercial vehicles. The most successful policies combine technology with driver training and incentive programs to encourage drivers to maintain speed limits. Examples of two companies using speed management policies are DHL and Southeastern Freight Lines.
For privately owned vehicles, other than direct consumer education the potential exists to return to the 90 kilometre per hour speed limit.

6.4 Driver Training Programs

Mainly suited to commercial applications, driver-training programs encompass training professional drivers in methods to drive the vehicles more efficiently. Having commercial vehicle drivers make a few simple changes to driving techniques can improve fuel savings by at least 5%.

Some elements of training programs that can reduce emissions are:

- Using cruise control where appropriate,
- Coasting where possible,
- Block-shifting,
- Braking and accelerating smoothly and gradually,
- Progressive shifting,
- Eliminating unnecessary truck idling,
- Reducing shifting, and
- Driving at the lowest engine speed possible.

Driver training programs often monitor driver performance and provide incentives to drivers who reduce fuel consumption and reduce GHG emissions.

7.0 Improving Transportation Resource Usage

Improving transportation resource usage reduces emissions in two ways. First by better utilizing vehicles it reduces pollution used in vehicle production and disposal. Second by encouraging better trip usage it reduces the total emissions as multiple trips are effectively bundled into one trip of the same length.

7.1 Carpooling

Carpooling is two or more people that commute to work together in a private vehicle. They organize their own agreements on who drives, who pays, and set their own schedules. In addition to reduced fuel consumption and emissions, carpooling also:

- Reduces commute costs,
- Decreases parking requirements,
- Reduces stress, and
- Decreases traffic congestion.
7.2 Vanpooling

Vanpooling is a more structured alternative to carpooling. A vanpool is made up of at least seven and up to fifteen people who live and work near each other and share approximately the same work hours. Riders pay a monthly fare based on the monthly round-trip mileage. Ideally vanpoolers should have similar work schedules, live at least 20 miles from work and normally spend at least 30 minutes driving each way.

In third party vanpooling the vehicle is owned and operated by a for-profit vendor. This is the most expensive of the three options. The second type of vanpooling is employer-sponsored. The employer purchases or leases vans and arranges for its operation. This is the least expensive option. Finally, in owner-operated vanpooling the van is owned by one or more of the group’s members. One of the vanpooling members uses their own vehicle and arranges for maintenance, insurance and billing.

7.3 Car Sharing

Car sharing is a relatively new concept to North America, but has been operating throughout Europe for numerous years. In car sharing a number of individuals who belong to a car sharing organization have access to one or more vehicles. The use of the vehicle is booked beforehand, and the user pays a fee based on the distance traveled and length of time the car was away. Members have 24-hour access to a network of vehicles stationed throughout the city, without having the costs of car ownership. It is a middle option between having no vehicle and owning a vehicle.

With car sharing you get the advantages of a car without the costs. Rather than everyone owning vehicles which they only use part of the time, car sharing provides vehicles in a neighbourhood that are available for member reservation and use. It is considered a cost effective alternative to owning a vehicle for individuals who drive less than 10,000 kilometres (6,000 miles) per year.

There are numerous advantages to implementing a car-sharing program. It reduces total per capita vehicle travel by encouraging alternatives to driving. It also reduces congestion, road and parking facility costs, and pollution. It makes driving affordable for lower-income individuals who only need occasional use of a vehicle. Fewer parking spaces are required as individuals shift from car travel to alternative modes. The result is increased ridesharing, public transit use, cycling, and walking. It also benefits the overall environment; with reduced amounts of vehicles on the roads. Equality between transportation modes is improved since there is an incentive to drive less once the full costs of driving become more visible in each trip.

Car sharing is most effective and appropriate in higher-density, lower and middle-income residential areas that have good alternatives to driving such as transit, cycling paths, etc.
Car sharing is also finding a use in commercial centers and industrial parks, as some small businesses are starting to use it as well.

Car sharing programs have been implemented in Victoria, Vancouver, Edmonton, Calgary, Toronto, Ottawa, Montreal, Quebec City, and Halifax. In the United States they have been used in New York, Washington, Philadelphia, Chicago, Boston, Seattle, Portland, San Francisco and several other cities. They have been operating across Europe for many years in Germany, Austria, Switzerland and Holland.

Three examples of car sharing are AutoShare in Toronto, City CarShare in California and Cambio operating in Europe.

7.3.1 AutoShare

AutoShare has been running in Toronto since 1998. They offer a membership for a $20 joining fee and a one-time $500 mobility membership, which is fully transferable. Incorporated in the standard plan, which is directed at individuals who need a car less than five times a month, is a $10 monthly fee, and rates of 15 cents per kilometre and $5 per vehicle hour on weekdays and $6 per vehicle hour on weekends.\textsuperscript{34}

7.3.2 City CarShare

City CarShare operates in San Francisco and the Bay area, and has been rapidly growing. City CarShare charges (prices in U.S. dollars) a $30 application fee, a $300 damage deposit and a $10 monthly fee. Their rates are $4 per vehicle hour during peak hours and $2 per hour during off-peak hours, as well as 44 cents per mile.

The University of California at Berkeley recently conducted a major study of the City CarShare operation. They found overall car use among members fell 47%, reducing car travel by 13,000 miles per year. Since joining the organization 30% of individuals have sold one or more of their vehicles. They also found that 84% of trips were cheaper using CarShare than taking taxis or car rentals.\textsuperscript{32}

7.3.3 Cambio

In Europe, Cambio is a fast growing car share organization, operating in Germany. Cambio currently charges a 600 Euro refundable deposit, 60 Euro registration fee and a 6 Euro monthly fee. Depending on the price class of vehicle chosen, hourly rates can vary from 1.70 to 3.70 Euros per hour and from 0.18 to 0.34 Euros per kilometre. Cambio is an innovative company and is planning to integrate smart card technology, so the same card can be used both as a pass on the city’s transit system and as a key to open one of their cars. They are also examining future options of integrating with taxi payment, to create a truly seamless multimodal payment system.\textsuperscript{35}
7.4 Park and Ride

Park and rides encourage better transportation resource usage by encouraging use of public transit for the longest part of the daily commute.

Park and rides are normally located on the fringe of large urban areas surrounding the city centre, and provide parking and a transfer point where individuals can leave their car and continue on into the city centre by public transportation. The facilities usually are located at transit stations, bus stops, mall parking lots, or near highway ramps. They are generally positioned to intercept motorists coming into town and prevent them from driving further.\textsuperscript{36}

They usually provide free parking or significantly less expensive parking than in the city centre. Normally high-quality, modern buses are used in order to attract users from their vehicles. Typically they are combined with other measures such as bus priority lanes.\textsuperscript{37}

The main goals of implementing a park and ride are to:

- Reduce traffic congestion,
- Reduce workplace parking demands,
- Increase travel via transit and ridesharing, and
- Shift individuals from single occupant vehicle travel to multi-occupant modes.

The main barrier to implementing park and rides is funding, with most requiring government subsidies. Security can be a barrier if the location is not perceived as safe from theft, vandalism or assault.

7.5 Bicycle Paths

Increasing cycling in a community can directly decrease the number of vehicle trips. Places that improve cycling conditions normally experience significant increases in bicycle travel and similar reductions in vehicle travel. It has been shown that transport policies and local attitudes can be more important than geography or climate in determining bicycle use. In Canada, generally, cycling usage would be higher if more suitable facilities and resources were available.

Some of the improvements that can be made to increase cycling are to:

- Improve paths and bike lanes,
- Fix road hazards such as potholes, cracks, narrow lanes,
- Improve bicycle parking,
- Implement traffic calming measures.
- Integrate cycling with transit, and
- Address the security concerns of cyclists.\textsuperscript{38}
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Broadly, there are three different categories of bicycle routes. Bicycle paths and trails are entirely separate from the roadway except at the occasional intersection. Bicycle lanes have a portion of the road marked with a line for cyclists. They are normally located on arterial roads and major collector streets. Bicycle routes are located on roads with lower traffic speeds and volumes, which are particularly suitable for cycling, and are marked with signs.39

To make cycling more attractive, proper facilities are also required. The location of bike racks must be in a highly visible area with surveillance so cyclists can find them readily and theft and vandalism is discouraged. Providing lockers, showers and changing rooms for employees who cycle to work is also needed, as this is one of the major deterrents for individuals choosing not to cycle to work.40

North America has a relatively low modal share of cycling transportation. By comparison the Netherlands has a split of 27% cycling and 44% vehicle travel, while Canada has 1% cycling and 74% vehicle travel. Copenhagen and Amsterdam have both implemented bicycle initiatives in their transportation plans to reduce the number of vehicles and reduce pollution.

Copenhagen implemented a City Bike Program in 1995, which placed 1,000 specially designed bikes at 120 stands around the city. They were mainly located at train and subway stations and parking lots. For a small deposit you can take a bike and ride wherever you want within downtown. Your deposit is given back when the bicycle is returned. The program has gone so well that more bikes were added every year. As of 2003 there were more than 2,500 bicycles operating in the program. Recently a similar program was implemented in downtown Toronto called BikeShare. For a small annual membership you can borrow and use a bicycle.36

7.6 Freight Transportation Management Systems

The volume of freight vehicle trips in cities is increasing and is expected to continue to increase even more in the future. This has been attributed to a number of factors, including: companies reducing inventories and requiring “just-in-time” deliveries, general economic growth, the rise in consumerism, as well as the growth of personal deliveries for electronic commerce. Typically, vehicle loads are low and many vehicles travel nearly empty.

Freight transport management systems attempt to:

- Reduce congestion and increase mobility, and
- Reduce pollution and noise.41

Measures designed to improve the efficiency of freight management typically attempt to increase load factors or to improve routing. Amongst these are:
Schedule co-ordination whereby multiple clients are served through one trucking company,
Digitized mapping to better plan routing,
Fleet management systems that better allocate vehicle size with demand, and
Off-peak delivery to reduce congestion and emissions.

Exel Worldwide is an example of an international logistics company that implements freight management systems for its customers. Using a ‘campus’ concept, numerous manufacturers selling consumer products are grouped and use the same distribution channels. Locating all companies in a central location enables them to share resources, and consolidate freight shipments. Normally if a store requested a truckload of soup and a truckload of cereal, they would go out on separate trucks. Under the Exel approach they are consolidated into one load, reducing traffic and emissions.\(^{42}\)

UPS uses driver-mapping technology as part of its approach to better freight management. Vehicles are periodically equipped with portable Global Positioning Satellite (GPS) systems and computers that map where the vehicle travels. The data is then examined for overlapping or inefficient routes. This increases productivity, improves fuel consumption and reduces emissions.\(^{43}\)

7.7 Company Mobility Plans

Company mobility plans are an overall management strategy implemented to change employees’ mobility patterns. Otherwise known as a green commuter plan or company transportation plan, these plans aim to reduce the number of private vehicles used to drive to and from work.

The concept of company mobility plans originated in the United States, and has rapidly spread across Europe. Each company develops a unique plan that fits the location and environment of the organization.\(^{44}\)

In addition to reduced emissions, companies that sponsor mobility plans benefit through:

- Improved productivity,
- Better public image,
- Better relations with its neighbors due to less traffic and noise,
- Reduced costs of providing parking, and
- Increased ability to attract and retain staff.

Employees have reduced expenses to travel to and from work and reduced commute stress.

An example of a successful company mobility plan is Nokia, located in Germany. Nokia had a problem of no direct public transportation connections to its plant, which employed approximately 2,600 people. To improve the accessibility Nokia co-financed better rail
connections with German railways. The results were modernization of the rail vehicle fleet, faster journey times, the introduction of weekend services, more frequent service at peak times, and improvements at the stops and stations. The outcome of this collaboration was that the number of passengers more than quadrupled.

8.0 Demonstration and Rewards Programs

Demonstration programs are designed to test new technologies that reduce emissions and have potential for adoption in wide spread application. Objectives may vary from simply proving the concept to full-blown real life application.

These range from simply showing specialized vehicles to the public and performing limited testing such as fuel cell demonstration cars to full scale in service day to day use. An example of the latter was the test of the Hydrogen Hybrid Internal Combustion Engine bus in Winnipeg during the winter of 2005.

In the freight business three of the more widely known national policies are Transport Canada’s Freight Sustainability Demonstration Program, the Voluntary Challenge and Registry Incorporated and the EPA’s sponsored SmartWay Transportation Partnership.

8.1 Freight Sustainability Demonstration Program

The Freight Sustainability Demonstration Program (FSDP) is a Transport Canada initiative created to help reduce the emission of greenhouse gases from the freight transportation sector. It aims to work with stakeholders to harness innovative ideas that reduce emissions in a practical and cost-effective manner.

8.2 Voluntary Challenge & Registry Inc.

The Voluntary Challenge & Registry (VCR) Inc. was established in October 1997. Its main goal is to encourage organizations from all sectors of the economy to accept greater accountability for GHG emission generation by undertaking voluntary actions. There are currently 1,236 companies registered.

The VCR operates the Entity GHG Challenge Registry. This is Canada’s only publicly accessible national registry of voluntary greenhouse gas baselines, targets, and reductions based on individual entities and/or facilities. The Canadian GHG Reductions Registry provides a service for organizations that wish to have GHG reduction projects validated and their annual emission reductions registered.

The VCR Champion Reporting System has three levels of reporting: Bronze, Silver and Gold. Each action plan is evaluated against a checklist using a point system to quantify the depth of the action plan. Bronze level requires 50 points, Silver level 70 points, and Gold level requires 90 points.
8.3 SmartWay Transport Partnership

The SmartWay Transportation Partnership is a collaborative voluntary program between the EPA and the freight industry designed to implement incentives for fuel efficiency improvements and greenhouse gas reductions. It focuses on market-based incentives that challenge companies to improve the environmental performance of their freight operations.

By 2012 SmartWay aims to reduce between 33-66 million metric tonnes of CO$_2$ emissions, 200,000 tonnes of NOx emissions per year, and create a fuel savings of up to 150 million barrels of oil annually.$^{46}$
Endnotes and References

24 This is the average of summer and winter months. Refer to Alberta Motor Association, “Vehicle Idling” www.ama.ab.ca/advocacy/Vehicle_Idling.pdf
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29 Manitoba was an early pioneer in Vanpooling. Refer to the report “*A Vanpooling Demonstration Project in Manitoba: the Concept, Feasibility of the Project and Site Selection.*” Underwood McLellan Ltd, 1979.
37 Lucas-Smith, Martin. “*Park andRide – Sustainable transport or expensive white elephant?*,” King’s College, Cambridge University, May, 2000.