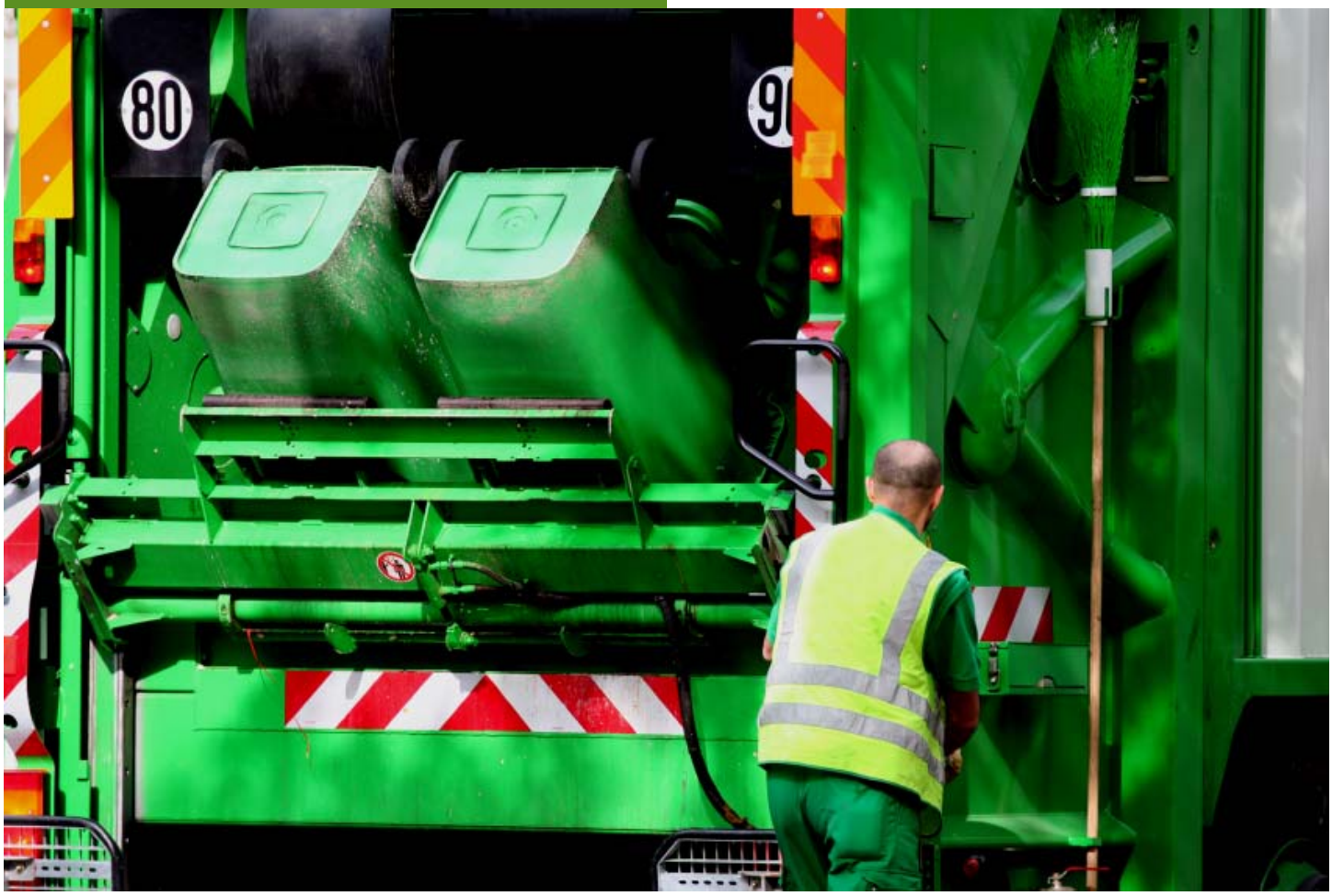
Partners
for Climate
Protection

Enviro-fleets: reducing emissions from municipal heavy-duty vehicles

A guide to helpful resources
June 2010



FCM | Federation of Canadian Municipalities

The Partners for Climate Protection (PCP) program is a network of Canadian municipal governments that have committed to reducing greenhouse gases and acting on climate change.

To help municipal fleet managers green their fleets, the Federation of Canadian Municipalities is expanding the PCP program with the **Enviro-Fleets** pilot project. Through **Enviro-Fleets**, FCM aims to help municipal fleet managers reduce GHG and CAC emissions associated with the operation of HDD fleet vehicles.

This guide would not have been possible without the generous funding support of Environment Canada and the Green Municipal Fund.

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How to use this guide

This guide is meant to assist municipal fleet managers, mayors, councillors and other municipal staff involved in fleet management to reduce emissions from heavy-duty diesel fleet vehicles. You can do this by making your vehicles more fuel- and cost-efficient.

Whether your municipality has already begun to green its fleet or is just beginning to explore ways of doing so, this guide provides information and resources to further your community's environmental and economic goals, and help you make the best choices for your community's needs.

The vehicles discussed in this guide are restricted to heavy-duty types[1], including snowplows, graders, street sweepers, sanitation and other waste diversion vehicles, heavy-duty trucks and the like. We do not include personal vehicles or smaller, light-duty vehicles used by municipalities. Nor do we include transit vehicles.*

Examples of green initiatives are highlighted in green throughout the guide. Text boxes provide you with a selected list of resources to help you learn more about a particular subject. The final pages of the guide include a Glossary.

* Although we do not include transit vehicles specifically in this guide, examples of some transit technologies that can be applied to other types of heavy-duty vehicles are included. For more information about transit vehicles, technologies and practices, consult the Canadian Urban Transit Association (http://www.cutaactu.ca/en/home) and Transport Canada (http://www.tc.gc.ca/).

[1] Heavy-duty diesel vehicles are defined as any class 6–8 vehicle with a gross weight rating of 3,856 kg (8,500 lb) or more, including, for instance, ambulances, fire trucks, snowplows and waste removal trucks.

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Introduction

Transportation and its links to climate change, human health and the environment

Transportation and climate change

The transportation sector as a whole is responsible for about one-quarter of Canada's GHG emissions[2]. GHGs have the potential to enhance the greenhouse effect enough to warm the planet at a rate never before experienced in human history. This may cause glaciers to retreat, sea levels to rise and climatic zones to shift. Depending upon emissions during the 21st century, most experts agree that average global temperatures could rise by one to 6.5 degrees Celsius during this century[3]. In Canada, this could mean an increase in annual mean temperatures, in some regions, that will be more than double global average increases.

Transportation emissions and human health

When it comes to transportation emissions, human exposure to smog—a mixture of ozone and particulate matter from vehicle exhaust and smokestacks—is of particular concern.

The Canadian Medical Association (CMA) reports that about 2,700 people die each year as a result of acute short-term exposure to air pollution and another 21,000 Canadians die from long-term exposure, with Ontario and Quebec having the largest proportion of acute premature deaths.

The CMA estimates the economic costs of this at $8 billion, a figure that could rise to $250 billion by 2031.[4]

Transportation emissions and the environment

The table below lists the major sources of vehicle emissions and their effects on both human health and the environment. See the Glossary for definitions of terms used here.

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2 Government of Canada. *Regulatory Framework for Air Emissions*. 2008. http://www.ecoaction.gc.ca/news-nouvelles/pdf/20070426-1-eng.pdf

3 Government of Canada. *Climate Change 101.* http://climatechange.gc.ca/default.asp?lang=En&n=65CD73F4-1: accessed May 2, 2010

4 Canadian Medical Association. *No Breathing Room: National Illness Costs of Air Pollution*. August 2008. http://www.cma.ca/multimedia/cma/content_Images/Inside_cma/Office_Public_Health/ICAP/CMA_ICAP_sum_e.pdf.

Impact of vehicle air emissions[5]

Type of emission	Is it a GHG?	Is it a Criteria Air Contaminant (CAA)?	Harmful effects and type of impact	Scale
Carbon dioxide	√		Climate change	Global
CFCs (vehicle air conditioners)	√		Ozone depletion	Global
Particulate matter		√	Human health, air quality	Local and regional
Hydrocarbons		√	Human health	Regional
Lead (in older fuel additives and batteries)		√	Human health (circulatory, reproductive and nervous systems)	Local
Methane (fuel production)	√		Climate change	Global
Nitrogen oxides	√	√	Human health, ecological damages	Local and regional
Ozone (smog-forming combination of nitrogen oxides and volatile organic compounds (VOCs))	√	√	Human and plant health	Regional
Sulfur oxides (diesel engines)		√	Human health, acid rain	Local and regional
Volatile organic compounds (from fuel production)		√	Human health	Local and regional
Carbon monoxide	√	√	Human health, climate change	Very local

[5] Transportation Sector Research Final Report, prepared by Marbek Resource Consultants Ltd. for FCM. http://www.sustainablecommunities.fcm.ca/files/Capacity_Building_Transportation/Transportation_Sector_EN.pdf.

By adopting more efficient practices to manage your fleet, your municipality can reduce harmful transportation emissions, noise, and the leaks and spills to water and soils associated with the transportation sector. A fuel- and cost-efficient municipal fleet will also save municipal governments money in operating and capital costs.

Why green municipal fleets?

Whether large or small, urban or rural, Canadian municipalities own and operate fleet vehicles to deliver a variety of municipal services. On average, Canadian municipal fleets are responsible for between three and five per cent of a municipality's total greenhouse gas (GHG) emissions and consume billions of litres of diesel and gasoline each year.[6]

However, depending on the size of the municipality and what fleet services it provides, the percentage of emissions from transportation can be much higher than average, leading to even higher operating and capital costs and poorer local air quality. Emissions from municipal and transit vehicles in Edmonton, for example, account for 20 per cent of the city's operations[7] and the municipal fleet of Halifax accounts for about eight per cent of all corporate emissions[8].

With the cost of fuel increasing as much as the need to reduce the environmental impact of fleet operations and meet municipal and national GHG reduction strategies, many municipal fleet operators have started to "green" their fleets by exploring the use of alternative fuels, improving operational fleet standards, and purchasing new vehicle types and technologies.

Municipalities that have already shifted toward greener fleet vehicles have discovered a host of benefits:

- Lower operating costs from fuel savings and more efficient vehicles
- Capital cost reductions from choosing properly-sized vehicles and eliminating older, inefficient vehicles
- Improved local air quality
- More efficient route planning
- Support for local economies by buying fleet-related products and services that are made locally.
- Opportunities to show leadership on environmental issues and meet municipal environmental goals.

This guide aims to describe and demonstrate the variety of measures that can be applied to heavy-duty diesel vehicles in your fleet in order to achieve these benefits. A green fleet plan that includes a strategy to reduce the emissions of heavy-duty vehicles will enable you as a Fleet Manager to implement a variety of measures with an understanding of how they fit together and how they should be prioritized.

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6 Transport Canada. *Biodiesel in Transit and Municipal Fleets*. http://www.tc.gc.ca/eng/programs/environment-utsp-biodieselintransitandmunicipalfleets-1067.htm.

7 Transport Canada. *Fuel Sense: Making Fleet and Transit Operations More Efficient*. http://www.tc.gc.ca/eng/programs/environment-utsp-fuelsense-1166.htm.

8 Halifax Regional Municipality. *Corporate Local Action Plan to Reduce Greenhouse Gas Emissions.* http://www.halifax.ca/environment/documents/HRMCorporateClimateLocalActionPlan.pdf.

Green fleet plans

Green fleet planning tends to focus on two main goals:

1. Optimizing vehicle use and efficiency (such as mode of travel, fuel type, route planning, fleet operation, and vehicle size), and
2. Increasing the use of alternative fuels and sustainable technologies.[9]

A green fleet plan may include:

- A **fleet and fuel management system** that identifies and evaluates fuel usage, asset tracking, vehicle right-sizing and life cycle optimization, vehicle sale and disposal, and other ways to improve efficiency.
- A **preventive maintenance program** that consists of scheduled inspection and follow-up repairs to vehicles and equipment with the goal of decreasing on-road breakdowns and excessive downtime.
- **Green maintenance and repair facilities**, such as those equipped with catch basins, low-energy lighting and heating systems, vehicle wash water recycling, environment-friendly cleaning fluids and well-maintained fuelling infrastructure.
- **Training and educational programs** designed to keep technicians abreast of new technologies and procedures and to educate drivers about fuel-efficient driving practices as well as the effects that new technologies may have on them and their driving practices.
- **Policies and procedures** that encourage green practices, such as anti-idling policies or green procurement policies, which promote the use of environmentally-responsible suppliers.
- The **use of hybrid vehicles**, such as diesel-electric or gasoline-electric, and
- The **use of alternative fuels**, such as biodiesel, ethanol, or others.[10]

Section 1 of this guide includes information on how to create a green fleet plan that will optimize the return on your investment of time and resources, by effectively reducing emissions.

Emissions from heavy-duty diesel vehicles

Strategies in a green fleet plan should consider the particularly concerning emissions of inefficient heavy-duty diesel vehicles. When used under identical conditions, diesel engines last about twice as long as gasoline engines and are much more fuel efficient. Diesel exhaust, however, is a significant source of criteria air contaminants (CACs) and greenhouse gases (GHGs).

CACs include emissions of sulfur oxides (SOx), nitrogen oxides (NOx), particulate matter (PM), carbon monoxide (CO), lead (Pb) and ground-level ozone (O3), which cause smog, acid rain and other health hazards. Modern Tier ii and Tier iii engines produce significantly lower levels of CACs but come with an increased maintenance demand that may add to maintenance costs.

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[9] Fleet Challenge Ontario, *Best Practices Manual 2008*, p. 11. http://www.fleetchallenge.ca/pdfnew/FCOntario_MuncipalBestPracticesManual2008.pdf.

[10] Fleet Challenge Ontario, *Best Practices Manual 2008*, p. 13-14.

Particulate matter is of special concern to human health because its microscopic size allows it to become trapped in the small airways of the lungs when it's inhaled. Diesel particulate matter is linked with health effects such as heart problems, aggravated asthma, chronic bronchitis and premature death.[11]

Navigating this guide

The sections that follow provide information on the specific technologies, fuels and measures that apply to reducing heavy-duty diesel emissions.

In Sections 1 through 4 of this guide you will find case studies that provide examples of how fleet greening measures have already been applied to municipal heavy-duty fleet vehicles across Canada. Resources are then listed for each section so that you may develop your own expertise on the subjects that pertain most to your fleet and the challenges you face in reducing emissions.

Section 5 of this guide discusses barriers faced by municipalities when working to reduce heavy-duty fleet emissions. Strategies and tools are recommended here to help you prepare for and overcome these barriers, including a list of financial incentives available to municipalities across Canada.

Section 6 identifies some of the most comprehensive and helpful green fleet resources and tools available to fleet managers and municipal decision makers. These resources are the result of the hard work of organizations across Canada committed to helping municipalities reduce the emissions of their fleet vehicles.

By collecting this information for you in one resource, we hope that this guide will add clarity and focus to the role of heavy-duty vehicles in your green municipal fleet.

[11] Puget Sound Clean Air Agency. http://www.pscleanair.org/programs/dieselsolutions/concerns.aspx.

Section 1–Developing plans, policies and training

Planning for success through a green fleet plan

An effective green fleet plan is necessary so you can decide how best to use resources.

The key components of an effective green fleet plan are

- fuel efficiency targets
- a GHG baseline, and
- an overall plan that includes goals, implementation strategies, milestones, roles and responsibilities, monitoring and reporting commitments, and a commitment from various levels of the organization to continuous improvement.

Benefits of a green fleet plan

A green fleet action plan shows that your municipality has a strong commitment to reducing emissions and it creates a roadmap for increasing the efficiency of fleet operations. If your plan calls for reduced fuel consumption, your municipality will also be reducing

- GHG emissions and CACs
- operating and insurance[12] costs.

It will help align key players such as fleet managers, decision-makers and other stakeholders, and will ensure that your municipality communicates clear and agreed-upon objectives.

Other benefits include an enhanced public image and pride among employees and within the community as a whole.

Creating a green fleet plan

Green fleet action plans should always start by calculating fuel consumption and baselines for GHG emissions. As with other planning of this kind, you will want your plan to identify and assess different strategies to most effectively reduce GHGs.

Some of the details contained in the Green Fleet Plan section of Fleet Challenge Ontario's 2008 Best Practices Manual are worth learning from. Here are the features the manual lists as contributing to successful green fleet plans:

1. A corporate culture that encourages environmental leadership.
2. A commitment to greening the fleet at the most senior level of the organization.
3. Carefully managed risk and a willingness to experiment.
4. A strong communications team to share successes.

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[12] Some insurance companies offer lower premiums for green vehicles (e.g., a 5% discount for clients with hybrids). Fuel-efficient driver training also promotes safe driving practices which may decrease on-road incidents and worker accidents. If a municipality can demonstrate an improved safety record, they can negotiate lower insurance premiums.

5. Your green fleet commitment, stated in policy.
6. A procurement policy that considers the value of life cycle costs
7. Planning that is both practical and carefully done.
8. Ability to capture reliable and consistent data on fleet operations.
9. Measurable, measured, and achievable green fleet goals.

As noted in #4 from this list, once complete, your green fleet action plan should be revealed to all stakeholders. This will maximize their commitment. Implementation should begin as soon as possible.

A well-configured system to manage fleet data will support #8 from the list above. This is an important asset to a green fleet, as it provides a tool to evaluate and identify areas for improving efficiency. It can also help you save as much as 20 per cent of annual operating budgets, if not more[13].

As with other corporate measures, the media and community should be included and kept aware of developments. By connecting the community to the success of your municipality at reducing GHG emissions, you will boost their desire to do likewise and increase their receptivity to current and future programs promoting awareness of and individual action to reduce emissions.

Learning from other municipalities

Many municipalities across Canada have devoted time and resources to creating complete plans that clearly lay out the measures and initiatives they will take to reduce emissions from their fleets. Both the City of Toronto and the City of Hamilton have been applauded for their fleet GHG reduction projects, which were guided by comprehensive green fleet action plans. The City of Toronto first took action through its Green Fleet Transition Plan: 2004–2007 and is now continuing to do so through its Green Fleet Plan 2008–2011. Both these documents are comprehensive and excellent resources to help other municipalities understand the actions you can take to green your own fleet.

The following municipalities have also created green fleet plans:

Delta, BC
http://www.corp.delta.bc.ca/assets/Engineering/PDF/green_fleet_mgmt.pdf

Oakville, ON
http://www.oakville.ca/Media_Files/2009SustainableGreenFleetGuide.pdf

Thunder Bay, ON
http://www.thunderbay.ca/Assets/City+Government/Departments/Dept+-+Facilities+$!26+Fleet/docs/Green+Fleet+Plan.pdf

Vancouver, BC
http://citywire.city.vancouver.bc.ca/es/GreenFleet.htm

[13] http://www.fleetchallenge.ca/pdfnew/FCOntario_MuncipalBestPracticesManual2008.pdf (Pg. 11)

Eliminating fleet vehicles

Getting rid of extra or inefficient fleet vehicles is known as downsizing or right sizing. An effective right-sizing strategy hinges on:

1. Developing a fleet inventory and vehicle usage data.
2. Identifying vehicles that can be reassigned or disposed of.
3. Planning how you will keep or remove vehicles that you identified in Step 2.

A good right-sizing strategy can help you reduce your fleet size by as much as 20 per cent.[14]

GREEN IDEA: The City of Williams Lake, B.C. made $44,000 at auction by getting rid of unnecessary or GHG-intensive vehicles and equipment. The city invested the money into its equipment reserve to help fund more energy-efficiency projects.[15]

GREEN IDEA: In Brampton, Ont., every vehicle in the city's fleet goes through a right-sizing review to ensure that the vehicle meets operational needs throughout its life cycle. Staff conduct cost-benefit and environmental impact analyses to reduce operating costs and CO_2 emissions.[16]

Right Sizing Resources

1. Effective Strategies for Increasing Fleet Utilization. http://www.mercury-assoc.com/resources/increase-fleet-utilization.pdf.

Adopting sustainable purchasing policies

More and more municipal governments are choosing to adopt sustainable purchasing policies, not only to reduce costs and support local economies, but for ethical and social reasons. The Sustainability Purchasing Network defines sustainable purchasing as:

> *A management process used to acquire products (goods and services) in a way that gives preference to suppliers that generate positive social and environmental outcomes, and that integrates sustainability considerations into product selection so that negative impacts on society and the environment are minimized throughout the full life cycle of the product.*[17]

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14 Mercury Associates. Government Fleet. July/August 2003. *Effective Strategies for Increasing Fleet Utilization*. http://www.mercury-assoc.com/resources/increase-fleet-utilization.pdf.

15 Civic Info BC. *Idling Reduction in the City of Williams Lake*. http://www.civicinfo.bc.ca/practices_innovations/idling_reduction_in_the_city--williams_lake--2009.pdf.

16 City of Brampton. http://www.brampton.ca/en/residents/Environment/Pages/green-fleet.aspx.

17 Sustainable Purchasing Network. *Integrating Sustainability into Purchasing*. http://www.buysmartbc.com/UserFiles/File/SPN_WS_25Sept08_SPN_PRESENTATION.pdf.

Some municipalities are now including minimum fuel efficiency standards or other green fleet specifications when they issue tenders for the purchase of new vehicles. Municipalities can award additional points for green vehicle-based bids and can also mandate the use of green vehicles in contracted services.[18]

Metro Vancouver's *sustainable procurement policy* came into effect in January 2007. It ensures that all purchasing decisions support the region's sustainable initiatives. In addition to asking bidders to provide information on pricing, delivery, experience and references, Metro Vancouver requires bidders to submit a declaration that they abide by all laws pertaining to the environment and workplace safety, as well as employment and human rights.[19]

GREEN IDEA: As part of its *Green Fleet Plan 2008–2011*, the City of Toronto requires all of its divisions to limit size of the city's fleet and to purchase fuel-efficient, right-sized vehicles as a standard practice, if they are commercially available and meet operational needs. Its *Green Vehicle Evaluation and Selection Tool*, funded by the Toronto Atmospheric Fund, helps fleet managers compare different kinds of heavy-duty technologies based on life cycle costs, GHG emissions, and CAA emissions. Currently, the tool only allows users to compare different types of class 8 garbage trucks but it will soon include other types of heavy-duty vehicles.[20]

Green Purchasing Resources

1. Sustainable Purchasing Network's *Integrating Sustainability into Purchasing*. http://www.buysmartbc.com/UserFiles/File/SPN_WS_25Sept08_SPN_PRESENTATION.pdf.
2. The City of Vancouver's *Supplier Code of Conduct* sets minimum performance standards under its ethical purchasing policy. http://vancouver.ca/sustainability/documents/AF01401P1.pdf.
3. The Commission for Environmental Cooperation has produced a sample purchasing policy template. http://www.buysmartbc.com/UserFiles/File/NAGPI%20Policy%20Paper2e-1.pdf.

Developing idling reduction plans and policies

One hour of engine idling is equal to two hours of driving. Vehicle engines that idle regularly for long periods of time typically need more servicing to replace spark plugs, fuel injectors, valve seats and piston crowns. Idling also reduces engine oil life by 75 per cent.[21]

One fleet program study (*Repair our Air*) analyzed engine data from 60 fleets between 2000 and 2005. Based on recorded vehicle operating times the analysis found that municipal fleets idle 30 to 50 per cent of the time and transit vehicles idle 35 to 40 per cent of the time.[22]

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18 Fleet Challenge Ontario. *Efficiency and Alternative Fuels. Natural Gas: Options for Municipal Fleets*. http://www.fleetchallenge.ca/pdfnew/workshop/Alicia_Milner-Cdn_Natural_Gas_Vehicle_Alliance.pdf.

19 Metro Vancouver. *Sustainable Procurement Procedures*. http://www.metrovancouver.org/bids/Bidding%20Documents/SustainableProcurementFAQs.pdf.

20 Personal communication with Sarah Gingrich, Business Development and Improvement Analyst Fleet Services, City of Toronto. March 30, 2010.

21 Fleet Challenge Ontario, *Best Practices Manual 2008*, p. 46.

Municipalities can take either a voluntary or regulatory approach to control idling. Voluntary approaches that include public education and focus on health tend to work best for the general public.

GREEN IDEA: Mississauga, Ont. enacted a new idling control bylaw in 2009 after a year long pilot project that encouraged motorists at a variety of locations to turn off their engines when parked. A mix of community based social marketing techniques with strong evaluation and monitoring processes showed that the length and frequency of engine idling in most of the sites chosen for the campaign were lower than elsewhere. Sites included schools and community centres, municipal fleet areas, and GO Transit stations.[23]

A more regulated approach may work best for municipal fleets, with the regulations becoming part of the municipality's corporate policy. Municipal regulations that address engine idling generally fall into one of two categories:

1. Stand-alone idling control bylaws; or
2. Anti-idling provisions within other bylaws (such as noise or nuisance bylaws).

Several municipalities have chosen the regulatory route by enacting stand-alone anti-idling bylaws.[24] These types of bylaws, however, are known to be very difficult to enforce (ticketing) and many do not set a specific fine for not obeying the bylaw.[25] Other municipalities have adopted included anti-idling provisions as part of their noise, traffic, nuisance abatement, or air quality bylaws.

GREEN IDEA: In 2005, the City of Hamilton, Ont. saved $300,000 in fuel costs and 720 tonnes of GHGs by controlling idling from municipal vehicles. It estimates that the city could save $2 to $3 million each year and reduce GHGs by 4,800 tonnes if the idling policy were fully enforced.[26]

GREEN IDEA: The City of Sudbury, Ont. targeted schools, the general public and municipal fleet drivers in its *Turn it Off* campaign. Almost 170 municipal fleet drivers took part in a survey to determine their attitudes and habits around idling. At the same time, anti-idling stickers were put on 600 municipal vehicles. The stickers reminded drivers to turn their engine off when stopped or parked. These efforts helped to reduce instances of idling from municipal vehicles by 40 per cent.[27]

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22 Fleet Challenge Ontario, *Best Practices Manual 2008*, p. 46.

23 Transport Canada. *Towards an Idle-Free Zone*. http://www.tc.gc.ca/eng/programs/environment-utsp-towardsanidlefreezone-1076.htm.

24 Ontario municipalities that have enacted stand-alone idling policies include Guelph, Kingston, London, Toronto, Niagara Falls, Pickering and Windsor.

25 Most existing bylaws do not specify a fine, but in a review of municipalities with stand-alone bylaws, the Clean Air Partnership found that fines ranged from $100 to $380. http://www.cleanairpartnership.org/situational_analysis_0405.pdf.

26 Fleet Challenge Ontario, *Best Practices Manual 2008*, p. 46.

27 City of Greater Sudbury. *Turn it off*. http://www.city.greatersudbury.on.ca/content/earthcare/documents/results%20and%20highlights%20presentation.pdf.

GREEN IDEA: The City of London, Ont. has had an anti-idling bylaw since 1999. The city's Middlesex Health Unit took the lead in developing the bylaw and was, originally, the only city department responsible for enforcing it. This role has now been expanded to include municipal law enforcement officers and parking control staff. The bylaw was also amended to lower the tolerance for idling from five minutes to two minutes. The health unit admits that enforcement is difficult, from a ticketing viewpoint, and has chosen to "blitz" certain areas of the city, such as truck stops and school yards, in order to educate drivers about the effects of idling engines on health and air quality.[28],[29]

Anti-Idling Resources

1. E3 Fleet–Idling Cost Calculator http://www.e3fleet.com/mc/page.do?sitePageId=40919&orgId=clcc
2. Clean Air Partnership. *A Model Idling Control Program for Municipal Fleets* (http://www.cleanairpartnership.org/pdf/model_idling_program_05.pdf)
3. Natural Resources Canada. *The Idle-Free Zone for Communities and Government*. http://oee.nrcan.gc.ca/communities-government/idling.cfm?attr=8. The site includes background information as well as ready-to-use materials (graphics, articles, fact sheets) and an idling impact calculator.
4. The Clean Air Partnership. *Situational Analysis: The Status of Anti-Idling Bylaws in Canada* provides an overview of existing bylaws and best practices. http://www.cleanairpartnership.org/situational_analysis_0405.pdf.
5. Natural Resources Canada. *The Carrot, the Stick and the Combo—A Recipe for Reducing Vehicle Idling in Canadian Communities*. http://oee.nrcan-rncan.gc.ca/communities-government/transportation/municipal-communities/reports/carrot-stick-combo/case-studies.cfm?attr=28. This review of 10 Canadian communities that implemented idle-free projects contains case studies and a list of the most important lessons learned.

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[28] Natural Resources Canada *Implementing an Idling Control Bylaw in London, Ontario*. http://oee.nrcan.gc.ca/transportation/idling/material/reports-research/london-by-law-report.cfm?attr=16. City of London, Ontario briefing note http://council.london.ca/meetings/Board%20of%20Control%20Agendas/2010-01-22%20Agenda/Item%207.pdf.

[29] Personal communication with Iqbal Kalis, Manager Environmental Health, City of London. March 31, 2010.

Ensuring drivers get training

Municipalities can purchase the most fuel-efficient vehicles on the market, but if drivers are not aware of how their driving habits affect fuel efficiency, maximum savings will not be realized.

Even without a formal training program, your municipality can share fuel-efficient tips with fleet drivers. As part of its *Drive Smart BC* program, the Insurance Bureau of British Columbia[30] offers these key tips for fuel-efficient driving:

1. **Slow down.** Speeding wastes gas and creates more GHG emissions. Driving below 90 km/h improves fuel efficiency and lowers emissions. Driving at 120 km/h in a 100 km/hr zone wastes up to 20 per cent more fuel than if you obeyed the speed limit.
2. **Accelerate smoothly.** Accelerating fast and braking hard increase GHG emissions and can increase fuel consumption by as much as 37 per cent.
3. **Keep tires well inflated.** Properly-inflated tires last longer, are less likely to skid and also reduce fuel consumption. For every four pounds per square inch (psi) tires are under-inflated, fuel consumption rises by two per cent.
4. **Plan the route.** By combining or planning regular municipal routes to be more efficient, drivers will reduce fuel consumption.
5. **Turn it off.** Idling for as little as 10 seconds wastes more fuel than it takes to restart the engine.

GREEN IDEA: The City of Edmonton requires all of its fleet drivers to take a four-hour training course on fuel-efficient driving practices. It includes both on-road and classroom training. To date, more than 800 fleet drivers have been trained, annual fuel consumption has been reduced by more than 10 per cent (200,000 litres a year), and GHG emissions were reduced by 310 tonnes.[31] In addition, its *Fuel Sense Incentive Program* motivates department heads to eliminate or downsize their fleet vehicles. Each department is charged a fixed fee for each vehicle and an additional charge per hour or kilometre (based on fuel, maintenance and repair expenses). They get to keep any savings if they are operating efficiently. As a result, total fleet size has dropped and the new vehicles purchased have generally been the smallest, most efficient ones that can meet departmental needs.[32],[33]

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30 ICBC. *DriveSmart BC*. http://www.drivesmartsavegreen.com/.

31 Transport Canada. *Fuel Sense: Making Fleet and Transit Operations More Efficient*. http://www.tc.gc.ca/eng/programs/environment-utsp-fuelsense-1166.htm.

32 City of Edmonton. *Fuel Sense Project*. http://www.edmonton.ca/environmental/documents/CityGov/FuelSenseProject.pdf.

33 Natural Resources Canada. *FleetSmart Profiles: Municipalities and Utilities*. http://fleetsmart.nrcan.gc.ca/index.cfm?fuseaction=docs.view&id=municipal-edmonton.

Driver Training Resources

1. Natural Resources Canada's SmartDriver training offers courses for a range of fleet types such as highway trucking, city fleets, transit and school buses. http://fleetsmart.nrcan.gc.ca/index.cfm?fuseaction=fleetsmart.smartdriver&attr=16.
2. The University of Toronto Driver Training Programme provides a training checklist at http://www.fs.utoronto.ca/recycle/greening/driver.htm
3. Port Metro Vancouver has partnered with Fraser Basin Council's E3 Fleet Program to offer a limited-time free Driver Review with Enhancement Training to company drivers and owner operators who service the Port: https://www1.pacificgatewayportal.com/tls4/Application/ShowFile.aspx?FileName=PMV_DriverTrainingAnnouncement2010.pdf.a2ca0bb2-65
4. The BC Climate Action Toolkit describes effective driver awareness and education training, including incentives: https://www1.pacificgatewayportal.com/tls4/Application/ShowFile.aspx?FileName=PMV_DriverTrainingAnnouncement2010.pdf.a2ca0bb2-65

Section 2–Conserving fuel

Wireless technology and global positioning systems (GPS)

Some private trucking firms and North American municipalities are now using software programs tied to their existing wireless networks (Wi-Fi) and to GPS technologies already installed in their fleet vehicles.

The Wi-Fi method captures vehicle location information using GPS and sends it from the vehicle to an existing cellular network. For example, when a fleet vehicle drives through an area with Wi-Fi coverage, information is automatically sent from the vehicle to the municipality's own network, without the driver needing to do anything.[34]

GREEN IDEA: Alberta Mobility and TELUS Mobility and Complete Innovations have introduced *Fleet Complete*, a GPS fleet tracking program that uses wireless networks. *Fleet Complete* collects information from on board the vehicle and delivers the data directly to an existing municipal or corporate network.[35]

Tracking fuel usage

Tracking fuel usage in municipal fleets can be as simple as asking drivers to record the information with pen and paper. Other options include outsourcing the task to a fleet management company or buying fuel-tracking software.

GREEN IDEA: The Town of Oakville, Ont. uses Computrol, a software program that tracks and reports fuel usage by vehicle ID number. The program provides daily, monthly and yearly data on fuel usage by liters used, fuel type, vehicle and department. The town has also equipped about 50 of its fleet vehicles with GPS to help plan the routes its fleet will use, thus reducing fuel consumption and emissions.[36]

Route planning (optimization)

Route planning (optimization) is a way to plan the shortest and most efficient routes for fleet vehicles. It can reduce fuel consumption, time spent on the road, vehicle kilometres driven and emissions.

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[34] Netistix. *Making the Business Case for Municipal Wi-Fi Networks Through Improved Transportation Programs*. http://www.netistix.com/uploads/pdfs/wp_metromuniWiFiApp.pdf.

[35] Alberta Association of Municipal Districts and Counties. http://aamdc.com/content/view/1200/473/.

[36] own of Oakville. *Sustainable Green Fleet Guide*. http://www.oakville.ca/Media_Files/2009SustainableGreenFleetGuide.pdf.

GREEN IDEA: For several years, the solid waste management division of the City of Toronto's works department, in collaboration with its Green Fleet Committee, used databases and historical information to calculate the shortest routes for many of its heavy-duty vehicles including garbage and recycling trucks, snow removal and salting trucks, and street sweepers. When it comes to garbage and recycling collection, Gilbert Siu, Manager, Operational Support, says that the city continually reroutes its trucks based on the number of homes and driver knowledge of the best and shortest routes. The city is now in the process of acquiring new software to further maximize route efficiency.[37],[38]

Intelligent transportation systems

Intelligent transportation systems (ITS) apply advanced and emerging technologies, such as computer software, sensors, controls, and communications and electronic devices to transportation. Some of these technologies are already in use, while others are being developed to improve transportation around the world. With ITS, computer and communication systems are integrated to provide an intelligent link among travellers, vehicles and infrastructure.

ITS includes a broad range of tools to make transportation systems more efficient. Some of these tools are

- automatic vehicle location systems (AVLS)
- geographic positioning systems (GPS), and
- real-time communication systems.

In Canada, ITS is most commonly used in transit operations but it could be used for other types of heavy-duty vehicles.

GREEN IDEA: In Winnipeg, AVLS has been installed on about 365 buses. It is connected to the transit control centre as well as to the city's existing traffic signal priority system. As a bus approaches an intersection it emits a signal detected by the traffic control system, which then initiates the appropriate signal phasing to either extend the green light or shorten the red light. The goal is to minimize bus delays. AVLS also provides real-time data that helps passengers by offering on-board stop announcements and schedule information through both a telephone and web-based system.[39]

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[37] Moving the Economy. *Toronto's Fleets and Route Optimization*. http://wx.toronto.ca/inter/mte/mte.nsf/0/0b25ac1681f01d1c85256812006a1f1f?OpenDocument.

[38] ICLEI. *Green Your Fleet*. Cited in: http://www.morpc.org/pdf/Green_Your_Fleet.pdf.

[39] City of Winnipeg. *WinSmart: Winnipeg for Sustainable Management Advancing Responsible Transportation. Final Report*. December 2009. Not yet published.

GREEN IDEA: TransLink's 98 B-Line between downtown Vancouver and Richmond, B.C., provides bus rapid transit service using ITS technology. AVLS, computerized monitoring of schedule adherence, traffic signal priority and real-time bus arrival information are all parts of the 98 B-Line's service. An evaluation of the 98 B-Line found that ITS led to annualized net benefits of $2.9 million, a 16 per cent reduction in transit travel times, a 20–25 per cent reduction in operating costs, and similar reductions in vehicle capital costs. Other benefits included a large increase in new riders and minimal disruption to corridor traffic operations.[40]

GREEN IDEA: The Region of Waterloo, Ont. installed AVLS on all its iXpress buses, which are part of the region's rapid transit system. AVLS communicates the bus's position and status to the dispatch centre, allowing controllers to monitor how well each bus is meeting its schedule and to detour buses around road collisions or major bottlenecks. The system is also connected to onboard mobile data terminals, which improves efficiency of the system by:

- Showing drivers how many minutes the bus is behind or ahead of schedule.
- Listing the bus's scheduled arrival time for the next three stations.
- Reminding drivers both visually and verbally to leave a station on time.
- Allowing drivers to communicate with the dispatch centre using text messages.

AVLS also supports real-time traveller information. Automated digital displays were installed on each bus and at every station. They provide next-bus information, actual departure times and scheduled departure times for conventional (non-rapid transit) routes, transit alert messages, public service announcements, weather information and advertising. On a passenger-kilometre basis, this combination of technologies has reduced GHG emissions by 3,650 tonnes.[41]

ITS Resources

1. Intelligent Transportation Systems Society of Canada (ITSCanada) is a professional non-profit organization that seeks to foster ITS applications, promote government-industry cooperation and strengthen the ITS industry. http://www.itscanada.ca/.

Vehicle maintenance

Regular inspections and maintenance are essential for keeping your fleet operating with minimal environmental consequences. Proper inspections and follow-up repairs usually improve fuel consumption by three to seven per cent and reduce emissions of particulate matter, NOx and VOCs by 10 to 20 per cent (actual reductions depend on the fleet's original condition).[42]

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[40] Transport Canada. *Intelligent Transportation Systems in 98 B-Line Rapid Bus Service: Advanced Technology at Work*. http://www.tc.gc.ca/eng/programs/environment-utsp-intelligenttransportationsystems-945.htm.

[41] Regional Municipality of Waterloo. *iXpress: Central Transit Corridor Express Project*. December 2009. http://www.grt.ca/web/transit.nsf/$All/F6DE7F8752F8C8C985257640004DC050/$file/Region%20of%20Waterloo%20UTSP%20Final%20Report%20Dec_09.pdf?openelement.

[42] United Nations Environment Programme. *Clean Fleet Toolkit.* http://www.unep.org/tnt-unep/toolkit/Actions/tool7/index.html

Setting up a maintenance program

A preventive maintenance program reduces vehicle downtime, helps you get the best fuel performance and emission reduction from a vehicle, and raises awareness of good maintenance practices. The list of items to be inspected is set as part of the program and vehicle maintenance is scheduled based on distances, engine hours, and/or time periods.

The benefits of a maintenance program include not only improved fuel performance and reduced GHG and CAC emissions but also longer vehicle life, improved driver safety and higher resale value. Although the effect of maintenance on fuel efficiency is difficult to measure, some fleets have estimated that regular maintenance may have improved fuel efficiency by up to 1.5 percent.[43]

Here are some steps to help you set up a maintenance program:[44]

- Identify and understand the manufacturer's maintenance standards.
- Consider warranty requirements.
- Involve all stakeholders—managers, drivers and mechanics/technicians.
- Make a list of all the maintenance tasks, from filter changes and proper tire pressure to 90,000 km vehicle tune-ups. Include as much as possible.

Often, only 10 to 15 per cent of vehicles in an ordinary fleet produce about 50 per cent of emissions. Proper inspection and maintenance programs can ensure that these vehicles are identified and repaired. Good maintenance will also extend the life of all parts of the vehicle, provide environmental benefits, and increase overall traffic safety.[45]

GREEN IDEA: The Town of Markham, Ont. practices "proactive preventative maintenance" that includes inspections and tune-ups on Town vehicles. Drivers inspect their vehicles daily and check tire pressure regularly to further improve overall fleet efficiency.[46]

Tires

Tires play a critical role in vehicle operation. By maintaining proper tire pressure and alignment, your municipality will reduce fuel use and tire wear. Some new tire designs can reduce fuel consumption by up to 4 per cent in dual tire configurations (two sets of wheels and tires at each end of the axle).

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43 Natural Resources Canada. *Fuel Efficiency Benchmarking in Canada's Trucking Industry*. http://oee.nrcan.gc.ca/transportation/business/documents/case-studies/fuel-effic-benchm.cfm?attr=16

44 The Province of BC. *BC Climate Action Toolkit.* http://www.toolkit.bc.ca/tool/preventative-maintenance-program

45 United Nations Environment Programme. *Clean Fleet Toolkit.* http://www.unep.org/tnt-unep/toolkit/Actions/tool7/index.html

46 Town of Markham. http://www.markham.ca/Markham/Departments/StratServ/EnvrLdshp/GreenFleet.htm

One such tire design, “super singles,” is lighter than two standard tires and wheels and costs less. On a combination truck using single wide-based tires on the drive and trailer axles, the weight savings will help you municipality reduce fuel consumption. As well, these wide-based tires have lower rolling resistance and aerodynamic drag, which helps to enhance fuel economy.[47]

Nitrogen tire inflation

Using nitrogen instead of conventional air in a tire will maintain the correct amount of tire pressure longer and as a result, create a smoother ride, improve steering and braking, and reduce the chance of blowouts. By contrast, compressed air in a tire contains 21per cent oxygen, which contains moisture and seeps through a tire wall up to 45 per cent faster than nitrogen. The moisture in oxygen molecules causes the rubber to wear out sooner than it needs to. This causes slow leaks and deterioration of the tire, which have an impact on how durable it is.

The direct and proven benefits of using nitrogen-inflated tires include:

- lower fuel consumption
- better gas mileage by up to 10 per cent[48]
- need to refill tires less often.

GREEN IDEA: BC Transit has a pilot program to use nitrogen tire inflation on all its buses. The program is expected to result in improved tire safety, fewer emissions, lower operating costs and fewer scrap tires as a result of extended tire life.[49]

GREEN IDEA: Although few examples exist of municipal vehicle fleets using nitrogen inflation, trials have been successful with private firms. Harrison Transport of Winnipeg, for example, paid $8,500 to convert 65 per cent of its fleet to nitrogen. The study looked at over 177 million tread-kilometres for 1,988 tire positions in 836 nitrogen-filled tires. A control group of 452 air-filled tires was also part of the study. Tread life in the nitrogen-filled tires was 86 per cent higher and greater fuel efficiency meant the company saved over 500,000 litres of fuel, or roughly $425,000 in fuel costs.[50]

Reducing vehicle weight

Transport Canada estimates that for vehicles powered by internal combustion engines, fuel consumption could be reduced by 0.235 litres/100 km for every 86 kilograms of mass reduction (reduced weight).

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47 GreenFleets British Columbia, http://greenfleetsbc.com/content/view/54/70/ and U.S. EPA, http://www.epa.gov/smartway/documents/supersingles.pdf.

48 GoNitroTire.com. Reported in http://boston.bizjournals.com/prnewswire/press_releases/Tennessee/2010/02/03/CL49024.

49 Live Smart BC. http://www.livesmartbc.ca/attachments/carbon_neutral_action_reports/BC_Transit.pdf.

50 Today’s Trucking. *Nitrogen inflation improves tread life, fuel economy: Study*. http://www.todaystrucking.com/newscenter.cfm?pageaction=story&intNewsCenterID=6&intDocID=18160&CFID=107191&CFTOKEN=60624993.

Vehicle weight affects fuel efficiency, so municipalities should request such information from the manufacturer when buying new vehicles. At the same time, it is important to note that lighter-weight vehicles must still be able to do the work they are supposed to do.

By using lightweight materials (high strength steel, aluminum, magnesium, titanium and various composite materials), manufacturers can reduce a vehicle's weight without sacrificing safety, durability or comfort. The more mass you can eliminate from a vehicle, the more you will improve fuel consumption.

Current aluminum technology can reduce the weight of conventional steel structures by half. Many manufacturers are already using aluminum to:

- build body structures or panels for vehicle hoods, trunk lids, doors and fenders
- replace cast iron for segments of the engine block, cylinder heads, transmission casings and intake manifolds, and
- replace steel forgings in the suspension, steering, axles, drive shafts and wheels.

Greater weight reductions are also possible using composite technologies such as reinforced polymer plastics, polycarbonates and carbon fibre. Composites such as these are now part of interior paneling, instrument panels, hoods and trunk lids. Polycarbonate roofs are also being installed on some new models, providing a 40 per cent reduction in weight over a similar glass roof model.[51]

Additional Technology Resources

1. Green Fleets British Columbia provides a listing of certain new vehicle technologies, some of which have been outlined in this guide. http://greenfleetsbc.com/content/view/22/36/
2. The U.S. Department of Energy provides a searchable database of vehicle manufacturers that supply clean technology vehicles (hybrid gasoline or diesel, electric, CNG, LNG and propane). http://www.afdc.energy.gov/afdc/vehicles/heavy/.
3. The U.S. Environmental Protection Agency has a Diesel Retrofit Verification Program supports the uptake of new technologies in the market while verifying that emissions reductions are accurately estimated. http://www.epa.gov/otaq/retrofit/index.htm

GREEN IDEA: The Puget Sound Clean Air Agency and their partners developed the Diesel Solutions[52] program to help local transit agencies, school districts, cities and counties, ports, ferries, cruise lines, garbage haulers and private businesses voluntarily clean up their fleets and equipment. All of the region's transit buses operate on ultra-low sulphur diesel and most of these buses have been fitted with diesel particulate filters. More than 1,500 of the region's school buses have also been retrofitted with DOCs. Programs are also underway to expand the number of municipal fleet and solid waste trucks burning cleaner fuels and equipped with diesel oxidation catalysts.[53]

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51 Transport Canada. *Lightweight and recyclable materials*. http://www.tc.gc.ca/eng/programs/environment-etv-materials-eng-117.htm.

52 Puget Sound Clean Air Agency. http://www.pscleanair.org/programs/dieselsolutions/.

53 Environment Canada. *Georgia Basin/Puget Sound International Airshed Strategy*. http://www.pyr.ec.gc.ca/airshed/Clean_Vehicles_e.htm.

Section 3–Reducing harmful emissions through technology

Diesel retrofit technologies

Diesel oxidation catalyst (DOC)

A diesel oxidation catalyst (DOC), also known as a diesel particulate filter, is a filter that either attaches to an existing muffler or replaces the existing muffler. Carbon monoxide and hydrocarbons react with oxygen in the presence of the catalyst, which thus removes them from the exhaust gas stream.

DOCs can be used on any diesel-fueled vehicle, including those that use low-sulphur or ultra-low sulphur diesel. They can be easily installed, require almost no maintenance, do not reduce performance or fuel efficiency, and are compatible with biodiesel. DOCs can remove up to 90 per cent of carbon monoxide and hydrocarbons, reduce particulate matter by between 15 and 30 per cent, and reduce noise.[54]

GREEN IDEA: In the summer and fall of 2005, Environment Canada partnered with the Greater Vancouver Regional District and eight local municipalities to retrofit approximately 70 municipal diesel engines with DOCs. This project reduced emissions from municipal diesel engines that typically operate in residential areas. The types of vehicles that were retrofitted include fire trucks, garbage/recycling trucks, dump trucks, sweepers and others. Participating municipalities included the City of North Vancouver, Delta, Vancouver, Maple Ridge, Whistler, New Westminster, Richmond and Mission.[55]

GREEN IDEA: The province of B.C.'s Air Action Plan, released in July 2008, included mandatory retrofits for all commercial heavy-duty diesel vehicles that operate on-road, by 2009. Retrofits involved the installation of DOC filters or any technology that worked as well as DOC filters. This strategy appealed to the province because DOC filters can be easily installed on most vehicles, require almost no maintenance, do not reduce performance or fuel efficiency, and are compatible with biodiesel. The initiative was expected to reduce emissions of fine particulate matter by at least 30 tonnes per year.[56]

Crankcase filters

Some filtration systems allow a diesel engine's crankcase to be closed while an air filter traps unburned fuel and blow-by gases. Known as a crankcase filter, this kind of filter can be added to existing vehicles to help prevent engine emissions from entering the vehicle cab. It is best used along with some type of exhaust retrofit. The device can reduce concentrations of fine

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54 Washington State University Extension Energy Program. http://www.energy.wsu.edu/documents/renewables/DieselOxidation.pdf.

55 Environment Canada. *Georgia Basin/Puget Sound International Airshed Strategy*. http://www.pyr.ec.gc.ca/airshed/BC_Municipal_Project_e.htm.

56 http://www.bcairsmart.ca/docs/bcairactionplan.pdf

particulate matter inside buses (particularly school buses) to match ambient air levels at a cost of about $400 to $600 per bus.[57]

GREEN IDEA: In 2008, the City of Denver, Colorado retrofitted 26 of its garbage trucks and 34 of its dump trucks with both DOCs and crankcase systems. The crankcase systems eliminated almost all emissions from the crankcase, while the two technologies used together reduced pollutants by 90 per cent.[58]

Emission Control Resources

1. Manufacturers of Emission Controls Association (MECA) is a U.S.-based non-profit organization that provides technical information on emission control technologies. http://www.meca.org/.
2. GreenFleets British Columbia offers a listing of diesel engine retrofit technologies that have been independently verified by the U.S. Environmental Protection Agency and the California Air Resources Board. http://greenfleetsbc.com/content/view/72/85/.
3. United Nations' Environment Programme (UNEP)'s Partnership for Clean Fuels and Vehicles includes a fact sheet on emissions control technologies as part of its Toolkit for Clean Fleet Strategy Development: http://www.unep.org/tnt-unep/toolkit/Actions/Tool11/Facts.html

Direct injection

A direct injection system in a diesel engine sprays fuel into the combustion chamber up to four times per cycle, creating a smoother, quieter operation that effectively captures more energy from each litre of fuel than older diesel engines.

Most of today's diesel engines inject fuel directly into the engine's cylinders using computer technology that delivers precisely the amount of fuel required when it's needed. Modern direct-injection diesel engines produce low amounts of carbon monoxide, CO_2, and hydrocarbons, even though emissions of particulate matter and nitrogen oxides still tend to be high.

Research is being done to find ways to meet tighter emission standards. This includes

- research into how soot and nitrogen oxide gases form
- research aimed at developing filter and removal technologies (such as DOCs), and
- research to improve diesel fuel itself.[59]

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57 Natural Resources Canada. http://oee.nrcan.gc.ca/communities-government/transportation/municipal-communities/school-bus-idling/appendix-f.cfm?attr=28.

58 City of Denver. *Greening Denver's Fleet*. http://www.denvergov.org/Portals/510/documents/Greening%20the%20Fleet%20-%20May%2029%20updates.pdf.

59 U.S. Department of Energy. *Freedom Car & Vehicle Technologies Program*. http://www1.eere.energy.gov/vehiclesandfuels/pdfs/basics/jtb_diesel_engine.pdf.

GREEN IDEA: The Port of Oakland in California oversees the city's seaport, international airport and 20 miles of waterfront. It has ordered nine heavy-duty liquefied natural gas trucks featuring high-pressure direct injection technology. The trucks will be used to haul containers to and from the seaport and are expected to reduce particulate emissions by as much as 85 per cent, according to port officials.[60]

Homogeneous charge compression ignition (HCCI)

HCCI is a form of internal combustion in which fuel and air are mixed in the combustion chamber, similar to a spark-ignited gasoline engine, but with a higher proportion of air to fuel. As the engine's piston reaches its highest point on the compression stroke, the air-fuel mixture auto-ignites (meaning that it completely combusts with no help from a sparkplug) due to compression. This ignition process is similar to that of a diesel engine in that it relies on compression to increase heat and temperature.

The technology works with both gasoline and E85 (85 per cent ethanol/15 per cent gasoline) fuel. It can lower fuel usage by 15 per cent and reduce emissions, particularly nitrogen oxides. On the other hand, HCCI requires stronger and more expensive engine construction and has a more limited power range than conventional sparkplug engines.[61]

Using auxiliary power units to reduce idling

During cold weather, municipal drivers will often leave a vehicle's engine running to help keep the truck's cab warm. This practice consumes fuel and emits diesel exhaust.

- Heating the cab or sleeper compartment of a heavy-duty vehicle by idling is very inefficient. It wastes over 85 per cent of the energy in the diesel fuel.
- Cooling the cab with air conditioning wastes 94 per cent of the energy in the fuel.

An auxiliary power unit (APU) is a portable, truck-mounted system that can provide climate control and power for trucks without idling.

Using auxiliary power units, some municipalities have now begun to install space heaters inside a truck's cab. APUs can be powered from a variety of sources including batteries, solar panels and separate small engines. They can also be incorporated into hybrid vehicles.

APUs cut fuel use by more than 80 per cent compared to idling, and they save wear and tear on the engine.

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60 LNG Plants. http://www.lngplants.com/CarsTrucksBusses.htm.

61 *HCCI—Homogeneous Charge Compression Ignition*. http://alternativefuels.about.com/od/researchdevelopment/a/HCCIbasics.htm.

There are two types of APUs: **direct-fired heaters** and **true APUs**.

Direct-fired heaters	True APUs
• They cost from $600 to $1,600. • They are usually engineered only to heat the cab. • They are powered in one of two ways: by the vehicle's battery alone or using a combination of the battery and diesel fuel. • To provide cooling, this kind of device requires a battery pack, which costs about $4,000.	• True APUs cost from $7,000 to $9,250. Generally diesel-powered, APUs consist of an internal combustion engine, compressor and alternator. They provide not only heat, but also air conditioning, and power to the cab without the need for idling. • This separate engine consumes between 0.38 to 1.14 litres of fuel per hour. This represents savings of 63 to 88 per cent over the three litres per hour that an idling engine consumes.[62]

GREEN IDEA: The City of Toronto uses space heaters in a number of its heavy-duty vehicles (cube vans, garbage trucks and aerial trucks). The heaters use a small amount of diesel fuel to heat the cab so that the driver can turn the vehicle off. In cube vans used by Toronto's water services division, the cab space is heated to allow work crews to warm up when they are outdoors on cold days. The space heaters reduce both emissions and fuel consumption.[63]

Idle stop technology

Idle stop technology shuts a vehicle's engine off when it does not need to be running and restarts it when the power demand increases. This is a feature that works best for vehicles that must make frequent stops and starts. In hybrid vehicles, idle stop technology saves fuel by powering the starter-generator from the regenerative braking system.

Both gasoline and diesel vehicles can use idle stop technology by using a more powerful starter-generator. Fuel is saved by powering the vehicle's generator through braking (using regenerative braking) as well as by powering certain controls and features (like lights and power steering) electronically, rather than directly from the engine.[64]

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62 Central Fleet Advisory Committee, City of Hamilton. *Green Fleet Implementation Plan, Phase 2 April 2009*: http://www.hamilton.ca/NR/rdonlyres/8094AD0B-EB16-4B63-929D-9B0815250FBA/0/PW03147cAppendixBGreenFleetImplementationPlanPhase2.pdf

63 Personal communication with Sarah Gingrich, Business Development & Improvement Analyst Fleet Services, City of Toronto. March 30, 2010.

64 Transport Canada. http://www.tc.gc.ca/eng/programs/environment-etv-idle-eng-113.htm.

GREEN IDEA: The City of Williams Lake, B.C. has three hybrid vehicles (a Toyota Highlander and two hybrid Honda Civics) that use idle stop technology. They are also equipped with a new kind of air conditioning system that uses an electric compressor to keep passengers comfortable when the engine is stopped.[65] Municipal services director, Kevin Goldfuss admits that fuel consumption savings on the Highlander have not been impressive, but says that because the vehicle is used for out-of-town travel only, it does not start and stop as much as vehicles used for in-town travel. Goldfuss also reports that the city's anti-idling policy (see the Idling Reduction section of this report) has saved the municipality 10 to 15 per cent in fuel consumption.[66]

State-of-the-art street sweepers

Regenerative air sweepers create a high-velocity air column that is then propelled into the top of the sweeping head through a blast tube. After the air is pressurized in the upper chamber of the sweeping head and expelled into the head's lower chamber, air is forced against the pavement at an angle. This high-volume blast of air loosens debris from pavement, transports it across the width of the sweeping head and lifts it into a containment hopper.

Unlike mechanical sweepers, regenerative air sweepers ensure that even hard-to-reach particles and particulate matter are removed, including PM10, known to contain a high percentage of heavy metals, phosphates and other pollutants.

GREEN IDEA: The City of Toronto has 50 regenerative air street sweepers. The technology at work in these machines reuses air in a closed-loop system and uses vacuum suction to pick up dust and other debris. These sweepers remove up to 90 per cent of particulate matter on city streets and result in a 21 to 30 per cent improvement in air quality.[67],[68] The City of Hamilton shared the testing protocol and joined Toronto's request for proposals, leading the city to purchase 16 regenerative air sweepers.[69]

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65 Civic Info BC. *Idling Reduction in the City of Williams Lake*. http://www.civicinfo.bc.ca/practices_innovations/idling_reduction_in_the_city--williams_lake--2009.pdf.

66 Personal communication with Kevin Goldfuss, City of Williams Lake. March 14, 2010.

67 Tymco Regenerative Air Sweepers. http://www.tymco.com/about/articles/cleansweep.htm.

68 http://www.toronto.ca/transportation/environment/index.htm#sweepers.

69 City of Hamilton. http://www.hamilton.ca/CityDepartments/PublicWorks/FleetServices/Fleet+News.htm.

Section 4–Making the shift to alternative fuels and vehicles

Ultra-low sulphur diesel (ULSD)

In 2006, Environment Canada amended its diesel fuel regulations to reduce the concentration of sulphur in diesel fuel from 500 ppm (parts per million) to 15 ppm. Starting with the 2007 model year, ultra-low sulphur diesel (ULSD) had to be used in engines equipped with advanced emission control systems. In 2007, Environment Canada further amended the regulations to reduce the sulphur concentration in "non-road" diesel fuel (locomotive and marine diesel) from 500 ppm to 15 ppm. [70]

Special care needs to be taken if you use ULSD with biodiesel because the fuels have different properties. In colder weather especially, biodiesel can separate in the fuel tank. This may plug filters and cause engine problems.

GREEN IDEA: Brampton, Ont. blends biodiesel with ULSD in all of its diesel-powered vehicles and equipment. Biodiesel blends range from B5 to B20 depending on the season.[71]

For most vehicle fleets, fuel is the highest cost item after labour. In some cases, the high cost of fuel can impact on a municipality's ability to deliver programs and meet responsibilities.[72]

The use of alternative fuels can be more expensive at the outset but over time this capital expense can be recovered through fuel cost and operational savings.

Biodiesel

Biodiesel is produced from renewable sources, such as vegetable and waste oils, or animal or fish fats. Hardly any engine modifications are needed to use biodiesel, which can be used as a pure fuel or mixed with petroleum diesel in any percentage. B5, B10 and B20 are the most common blends (a 5 per cent, 10 per cent or 20 per cent blend, respectively), with B5 and B10 commonly used in colder weather to avoid fuel engine gelling.

Cost and availability tend to be the biggest challenges associated with the use of biodiesel. Some communities have access to waste oils from other manufacturing or processing facilities and this can reduce the costs.

On average, biodiesel is more expensive than gasoline. However, depending on the type of biodiesel used,[73] the existence of provincial incentives or tax exemptions for producing biodiesel, and other factors, the cost per litre of biodiesel can be competitive.

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70 Canadian Petroleum Products Institute. *Ultra Low Sulphur On-road Diesel (ULSD)*. http://www.believeinit.ca/userfiles/pdf/ULSD_Q&A_e.pdf.

71 City of Brampton. http://www.brampton.ca/en/residents/Environment/Pages/green-fleet.aspx.

72 Fleet Challenge Ontario, *Best Practices Manual 2008*, p. 45.

73 Since biodiesel can be made from many different sources, geography plays a role in the kinds of biofuels that may be available. For example, Halifax has access to biodiesel made from waste fish oils, while Brampton's biodiesel is made from soybeans.

Using 100 per cent biodiesel reduces carbon dioxide emissions by 75 per cent compared to petroleum diesel, while a B20 blend will reduce emissions by about 15 per cent. The table below shows the kinds of emission reductions linked to a shift to biodiesel.

Average biodiesel emissions compared to conventional diesel[74]

Emission Type	Reductions based on a B20 biodiesel blend
Total unburned hydrocarbons	-20%
Carbon monoxide	-12%
Particulate matter	-12%
Nitrous oxides	+2% to –2%
Sulfates	-20%
Polycyclic aromatic hydrocarbons	-13%

Although biodiesel can be used in any diesel engine with little or no modification to the engine or the fuel system, biodiesel is incompatible with the natural rubber seals and hoses used in older engines. (Newer engines use synthetic materials that are not affected). Because biodiesel is a solvent that will remove deposits from storage tanks and engines, the release of such deposits can clog filters initially. You will need to ensure you replace fuel filters until the petroleum build-up is eliminated. This issue is less common with B20 blends, and there is no evidence that lower-blend levels such as B2 cause filters to plug.[75]

The Province of Ontario exempts biodiesel from its 14.3 cents per litre provincial tax and the federal government exempts it from the four cents per litre federal excise tax.

GREEN IDEA: After a pilot project with 16 vehicles, in 2003 Brampton, Ont. became the first municipality in Canada to use biodiesel made from soybeans in all of its fleet vehicles and equipment. Brampton Transit began using biodiesel in 2004. Today, the city uses 8 million litres of blended biodiesel fuel. The Ontario tax exemption for biofuels helped Brampton to offset the higher cost of using biodiesel.

GREEN IDEA: Halifax Regional Municipality uses biodiesel made as a byproduct from the processing of Omega-3 fish oils in all of its transit buses and some of its ferries. The municipality suspended the use of biodiesel due to quality issues in 2005—it had been using a B20 mixture—but resumed its use in January 2007 with a B5 blend.[76] An analysis by Environment Canada's Environmental Technology Centre in 2004 showed that although the use of biodiesel in the city's transit buses did not substantially improve fuel consumption, it did reduce total hydrocarbon emissions by 19 per cent, carbon monoxide by 28 per cent and particulate matter by 15 per cent. Analysis also determined that the additional cost of using biodiesel was roughly two-tenths of a cent per litre.[77]

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74 U.S. Department of Energy. Alternative Fuels Data Center.

75 Puget Sound Clean Air Agency. http://www.pscleanair.org/programs/dieselsolutions/fuels/biodiesel.aspx.

76 Halifax Regional Municipality. http://halifax.ca/metrotransit/Biodiesel.html.

77 Transport Canada. *Biodiesel in Transit and Municipal Fleets*. http://www.tc.gc.ca/eng/programs/environment-utsp-biodieselintransitandmunicipalfleets-1067.htm.

Biodiesel Resources

1. Canadian Renewable Fuels Association provides a list of biodiesel and ethanol producers in Canada: http://www.greenfuels.org/lists.php.
2. The U.S. Environmental Protection Agency provides a free biodiesel emission reduction calculator at: http://www.epa.gov/dieselretrofit/techlist-biodiesel.htm.
3. For an E3 Fleet Biodiesel Calculator, visit: http://www.e3fleet.com/mc/page.do?sitePageId=38606&orgId=clcc
4. For more information on biodiesel demonstration projects, visit Natural Resource Canada's Office of Energy Efficiency website: http://oee.nrcan.gc.ca/transportation/fuels/biodiesel/biodiesel-projects.cfm?attr=169

Compressed natural gas (CNG)

Compressed natural gas (CNG) is a low-carbon fuel that can be used in commercial vehicles with new technologies and in aftermarket conversions. Several of the leading manufacturers of transit buses and garbage trucks offer CNG as an option built in at the factory.

As the third largest producer of natural gas in the world, Canada has an 80-year supply in its remaining resources. As shown in the table below, compared to gasoline and diesel, CNG creates fewer GHG emissions.

Type of Fuel	Grams of eCO2/MJ
Gasoline	92.8
Diesel	91.6
Compressed natural gas	68.1

Compared to heavy-duty diesel-powered vehicles, CNG vehicles emit 39 per cent fewer volatile organic compounds.

Compared to vehicles using traditional fuels, CNG-powered vehicles can reduce lifecycle GHG emissions by as much as 17 tonnes per year for transit buses and 10 tonnes per year for garbage trucks. Biomethane—produced from feedstocks such as municipal solid or organic waste, wastewater treatment solids or landfill gas—can also be used in conventional natural gas vehicles.

In Ontario, estimates show the cost to convert to CNG is about $5,000 per vehicle. Fuel savings over the life of the vehicle more than cover the upfront costs and added maintenance.[78]

GREEN IDEA: In Moose Jaw, Sask., 13 pickup trucks from a total fleet of 50 were converted from gasoline to CNG. The municipality plans to convert new pickup trucks as they are acquired. Fleet drivers can refuel at a public CNG station on city property. The city's payback period is about one year on an average vehicle lifespan of 12 years.[79]

[78, 79,] Fleet Challenge Ontario. *Efficiency and Alternative Fuels. Natural Gas: Options for Municipal Fleets*. http://www.fleetchallenge.ca/pdfnew/workshop/Alicia_Milner-Cdn_Natural_Gas_Vehicle_Alliance.pdf.

GREEN IDEA: The City of Hamilton, Ont. operates Canada's largest fleet of natural gas-powered transit buses. Beginning in 1984, the Hamilton Street Railway Company (the city's public transit authority) began converting buses from diesel to CNG. The biggest benefit has been the cost savings of CNG compared to diesel fuel. For CNG buses, in 1996 the average operating cost per kilometre was $0.60 for 1991 vehicles and $0.42 for 1992 ones. The average operating cost for its1989 diesel buses was $0.72 per kilometre. The 1991 CNG buses were, therefore, 16.7 per cent less expensive to operate than diesel-powered buses, while the 1992 CNG buses were 41.7 per cent less expensive to operate.[80]

Natural Gas Resources

1. Fleet Challenge Ontario and Natural Gas Vehicle Alliance. *Efficiency and Alternative Fuels. Natural Gas: Options for Municipal Fleets*. http://www.fleetchallenge.ca/pdfnew/workshop/Alicia_Milner-Cdn_Natural_Gas_Vehicle_Alliance.pdf.

Ethanol

In Canada, ethanol (ethyl alcohol) is most often made from corn and wheat. Cellulosic ethanol, on the other hand, is made from a much wider range of materials including leftover agricultural, forestry and organic wastes, including cereal straws, corn stalks, organic municipal solid waste, sawdust and paper pulp. These feedstocks can be combined in cellulosic ethanol.

Iogen Corporation of Ottawa has pioneered the use of straw-based cellulosic ethanol using straw provided by local farmers. As of June 2009, gasoline sold at all Ottawa-area Shell gas stations contained 10 per cent cellulosic ethanol.[81]

Both ethanol types are renewable fuels that burn more cleanly and completely than gasoline or diesel. Ethanol helps cut GHG emissions because the grain or other biomass that was used to create it absorbs carbon dioxide as it grows.

Ethanol can be blended with gasoline to produce a fuel that has environmental advantages when compared with gasoline. It can be used with no modifications in gasoline-powered vehicles built during the 1980s. Most gasoline-powered vehicles can run on a blend of gasoline and up to 10 per cent ethanol, known as E10, which is available at some regular service stations across Canada. E10 produced from corn produces three to four per cent fewer GHG emissions compared to gasoline. E10 produced from cellulosic materials produces six to eight per cent fewer GHG emissions.

It is becoming a common practice in North America to blend ethanol with gasoline at concentrations of seven to 10 per cent by volume. Ontario's renewable fuels standard, for example, requires gasoline sold in the province to contain an average of five per cent ethanol. All cars built since the 1970s are fully compatible with up to 10 percent ethanol (E10) in the fuel mixture.

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[80] Natural Resources Canada. *FleetSmart Profiles: Municipalities and Utilities*. http://fleetsmart.nrcan.gc.ca/index.cfm?fuseaction=docs.view&id=municipal-hamilton.

[81] E3 Fleet. http://www.e3fleet.com/mc/page.do?sitePageId=102677&orgId=clcc.

GREEN IDEA: The governments of Alberta and Ontario currently exempt the ethanol portion of blended gasoline from their road taxes, with no restrictions on the ethanol's source or content. The governments of Saskatchewan and Manitoba offer an exemption from their road taxes for fuel ethanol produced and consumed in those provinces. The governments of British Columbia and Quebec have committed to exempt the ethanol portion of low-level ethanol blends from their road taxes when an ethanol plant is built in their provinces. British Columbia currently offers a road tax exemption on the ethanol portion of E85.[82]

GREEN IDEA: Most of the City of Ottawa's re-fuelling sites have been converted to E10, a blend of 10 per cent ethanol and 90 per cent gasoline. As a result, carbon monoxide (CO) and carbon dioxide (CO^2) emissions will be reduced by one tonne and 250 tonnes per year, respectively.[83]

As in gasoline vehicles, low level blends of ethanol and diesel fuel can be used in diesel vehicles without modifying the engine. However, because of the way they operate, diesel engines present special technical challenges for fuels that contain high levels of ethanol. One of these challenges is that ethanol resists self-ignition. To use high-level ethanol blends in a diesel engine, one of two things must happen: the engine must be modified to improve its ability to ignite the alcohol or ignition "improvers" must be added to the fuel.[84]

Ethanol Resources

1. The Canadian Renewable Fuels Association provides a list of biodiesel and ethanol producers in Canada: http://www.greenfuels.org/lists.php.

Hydrogen fuel cells

A hydrogen fuel cell operates like a battery, with two electrodes—an anode and a cathode—separated by a membrane. [85] Like a battery, these fuel cells convert chemical energy directly into electricity. In this case, the fuel cell combines hydrogen and oxygen to produce electricity, heat and water. As long as hydrogen fuel and air are supplied, this kind of fuel cell will produce DC electricity without needing to be recharged.[86]

P-series fuel

Designed to be used alone or mixed in any concentration with gasoline, P-series fuels are clear liquid fuels, between 89 and 93 octane, for use only in flex-fuel vehicles (FFVs). This kind of fuel

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82 Natural Resources Canada. http://oee.nrcan.gc.ca/publications/infosource/pub/vehiclefuels/ethanol/M92_257_2003.cfm.

83 City of Ottawa. Fleet Emission Reduction. http://www.ottawa.ca/residents/environment/workplace/fleet_emission_en.html

84 Natural Resources Canada. http://oee.nrcan.gc.ca/publications/infosource/pub/vehiclefuels/ethanol/M92_257_2003.cfm.

85 http://inventors.about.com/od/sstartinventions/ss/Physics_Illustr_2.htm.

86 Natural Resources Canada. http://oee.nrcan.gc.ca/publications/infosource/pub/ici/caddet/english/DO35.cfm?attr=20.

is a blend of 35 per cent natural gas liquids (pentanes plus) and 45 per cent ethanol, with the other 25 per cent composed of a biomass-derived cosolvent called methyltetrahydrofuran (MeTHF). The biomass portion is made from grass and paper waste, along with agricultural waste.[87]

In 1999, the City of Philadelphia, Pennsylvania, conducted a successful demonstration of P-series fuel in a flex-fuel car (a Ford Taurus) and has since added these vehicles to its fleet.[88]

The most common flex-fuel vehicles tend to be light-duty cars and trucks. A literature review reveals very little about the use of flex-fuel technology or P-series fuels for heavy-duty vehicles. Some manufacturers, however, are now starting to offer heavy-duty flex-fuel vehicles, which could be candidates for P-series fuels.

Propane (liquid petroleum gas)

Propane, also known as liquefied petroleum gas (LPG), is produced as part of natural gas processing and crude oil refining. In natural gas processing, the heavier hydrocarbons that occur naturally in natural gas, such as LPG, butane, ethane and pentane, are removed before the natural gas enters the pipeline distribution system. In crude oil refining, LPG is the first product created, and is therefore always produced when crude oil is refined.

LPG is made of single chemical compounds, which allows for more complete combustion than conventional fuels. Compared to diesel vehicles, LPG vehicles cut carbon dioxide emissions from heavy-duty engines by 90 per cent, nitrous oxide emissions by about 60 per cent and they almost eliminate particulate matter.[89]

Propane is a low-emission, economical, and easily-used fuel that can be turned into a liquid under moderate pressure of 160 pounds per square inch (psi). It is stored in pressure tanks at about 200 psi at 100ºF. When propane is drawn from a tank, it changes to a gas before it is burned in the engine. More than four million vehicles fueled by propane are in use around the world for light, medium, and heavy-duty uses.

Propane holds approximately 75 per cent of the energy of gasoline and so more of it (greater volume) is needed to drive the same distance. Overall, its cost competes well with gasoline in terms of fuel economy. It takes 1.36 litres of propane to travel the same distance as one litre of gasoline[90]. Even when this difference is factored in, propane can be about 25 to 30 per cent cheaper than gasoline, depending on its local cost. Also, because propane weighs less than gasoline, propane tanks can be bigger without affecting vehicle acceleration.

LPG vehicles provide power, acceleration, and a cruising speed similar to gasoline vehicles. However, propane trucks, like many other vehicles powered by alternative fuels, typically have a shorter driving range than their diesel counterparts. This occurs because propane has a lower energy density and because it's hard to mount the high-pressure storage cylinders on a truck.

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87 About.com. http://alternativefuels.about.com/od/pseries/a/Pseries101.htm.

88 E-Wire http://www.ewire.com/display.cfm/Wire_ID/33 and Pure Energy http://www.pure-energy.com/press/061899pr.html.

89 Cleaner Vehicles Task Force. *An Assessment of the Emissions Performance of Alternative and Conventional Fuels.* http://www.cleanairnet.org/infopool/1411/articles-35613_assessment_emission.pdf.

90 Central Fleet Advisory Committee, City of Hamilton. *Green Fleet Implementation Plan, Phase 2 April 2009*: http://www.hamilton.ca/NR/rdonlyres/8094AD0B-EB16-4B63-929D-9B0815250FBA/0/PW03147cAppendixBGreenFleetImplementationPlanPhase2.pdf

Adding additional storage tanks can increase the truck driving range, but the added weight will reduce the amount of weight the vehicle can carry.[91]

Although Natural Resources Canada reports that only one automaker in North America is manufacturing propane-powered vehicles, conventional gasoline vehicles can be converted to run on propane, or on propane and gasoline, using a certified conversion kit.[92]

GREEN IDEA: Since the 1980s the Region of Peel, Ont. has used propane for its fleet of 40 para-transport vehicles. These buses must keep running at all times to keep passengers warm in winter and cool in summer. Because the buses are often stopped outside hospitals, the region wanted to lower the vehicle emissions in these sensitive areas. The region had a hard time using propane only, particularly on V-10 engines, because of poor performance and backfires, which led to increased maintenance. In time, the region adopted an electronically controlled fuel injection system that favours propane use while also allowing the fuel to be automatically switched between propane and gasoline based on conditions at any given time. These changes have achieved fuel savings of between 15 and 20 per cent over gasoline, higher fuel mileage by approximately 22 per cent, and have reduced the amount of maintenance required on each vehicle.[93]

Propane Resources

1. Propane Education & Research Council http://www.propanecouncil.org/Fleet.aspx?id=3316
2. E3 Fleet Fuel GHG Calculator http://www.e3fleet.com/mc/page.do?sitePageId=34936&orgId=clcc

Flex-fuel vehicles (FFVs)

Some automakers make flex-fuel vehicles (FFVs) that can run on E85, a blend of 85 per cent ethanol and at least 15 per cent gasoline. (The 15 per cent gasoline is needed because pure ethanol does not ignite well in cold weather). The E85 blend cannot be used in standard gasoline vehicles.

Although E85 is now being used by some North American organizations with large vehicle fleets, it is not yet commercially available in Canada.[94] In fact, the only station that provides E85 fuel for general use is in Ottawa.

E85 vehicles come equipped with a sensor to detect and adjust to the fuel mixture being used at any given time. The handling of E85's high alcohol content requires that engine intake valves, fuel-injection systems and ignition systems be different from those in gasoline-powered vehicles. Certain parts of these vehicles must also be made of alcohol-resistant materials since zinc, lead, magnesium, aluminum and certain plastics and rubbers that are common in standard

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91 Green California. http://www.green.ca.gov/EPP/Vehicles/heavyDV.htm.

92 Natural Resources Canada. http://oee.rncan.gc.ca/publications/infosource/pub/transportation/fuels-in-canada.cfm?attr=20#propane.

93 EDPRO. *Peel Region TransHelp's Experience,* http://edproenergy.com/solutions/fleet/casestudy2.php and Region of Peel. http://www.peelregion.ca/corpserv/stratplan2003-2006/goals.htm.

94 Natural Resources Canada. http://oee.nrcan.gc.ca/transportation/fuels/ethanol/ethanol.cfm.

vehicles can be broken down by alcohol. For example, flex-fuel vehicles require stainless steel storage tanks and fuel lines. To overcome the lower energy content of ethanol, manufacturers have equipped E85 vehicles with larger fuel tanks.[95]

GREEN IDEA: The City of Stockholm, Sweden, operates a fleet of flex-fuel vehicles using E85. About 15 per cent of the bioethanol used for these vehicles is produced in Sweden. The city's data shows that, compared to gasoline, E85 vehicle emissions of nitrogen oxides are 50 per cent lower. Carbon monoxide emissions are 15 to 20 per cent lower. Finally, despite using about 40 per cent more fuel per kilometre (by volume), on a lifecycle basis the vehicles using E85 cut overall GHG emissions by 75 per cent.[96]

Flex-Fuel Resources

1. To find a refuelling station that carries E10 ethanol-blended gasoline: http://oee.nrcan.gc.ca/transportation/personal/find-refueling-station.cfm?attr=16.
2. AFV Guide. This software package helps you determine the cost-effectiveness of buying newly-built vehicles that can operate on certain alternative fuels, including E85. http://oee.nrcan.gc.ca/transportation/tools/afvGuide/index.cfm?attr=16.

Diesel-electric hybrids

Diesel-electric trucks combine an internal combustion engine with an electric motor, rechargeable batteries and a regenerative braking system that captures and reuses the energy lost during traditional vehicle braking. Vehicles that must make many stops and starts, like garbage trucks and transit buses, make the best use of regenerative braking systems. For this reason, most of the diesel-electric hybrids on Canadian roads tend to be transit vehicles.

GREEN IDEA: By the end of 2010, the City of Ottawa's transit fleet will include almost 200 hybrid diesel-electric buses. With the help of the National Research Council, the city tested two different types of buses, finally settling on the Orion VII Next Generation model. Each bus costs about $675,000, a higher price than a conventional diesel bus (about $500,000), but with a longer lifespan. The city estimates the payback period to be about six years. Jean-Yves Carrier, program manager with the city's transit authority, OC Transpo, says that to get the most from hybrid buses, they should be used on routes with at least three stops per kilometre.[97] The city is also converting all of its fleet vehicles to use biodiesel. In transit vehicles alone, this is expected to cut GHG emissions by 8,946 tonnes each year.

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95 Natural Resources Canada. http://oee.nrcan.gc.ca/transportation/fuels/ethanol/availability.cfm?attr=16.

96 BioNETT. *Stockholm's Municipal Fleet of Bioethanol FFVs*. http://www.bio-nett.org/Stockholm's-Municipal-Fleet-of-Bioethanol-FFVs-Case-Study.pdf.

97 Federation of Canadian Municipalities. *Ottawa's hybrid diesel-electric transit buses*. http://www.sustainablecommunities.fcm.ca/files/Capacity_Building_-_PCP/PCP-GHG_initiative_of_the_month/Ottawa_GHG_Initiative-aug09-EN.pdf.

Unlike hybrid passenger vehicles, heavy-duty hybrid diesel-electric vehicles are only just now becoming commercially available. The first hybrid diesel-electric garbage truck, for example, was introduced in Sweden in 2008.[98] Some Canadian municipalities, such as Regina, are hoping to purchase one for a test project,[99] while cities such as New York and San Francisco have already begun pilot projects with the vehicles.

Transport Canada estimates that some 200,000 garbage trucks operate in North America and that they use up to 4 billion litres of diesel fuel each year. Switching one conventional truck to a hybrid could save 5,000 litres of fuel and reduce GHG emissions by 13 tonnes annually.[100]

GREEN IDEA: The City of Toronto's forestry division uses three hybrid aerial tower trucks for trimming trees. These class 8 diesel trucks use a hybrid electric system that can raise, lower and move the bucket, propel the vehicle at low speeds, and operate the vehicle's lights and other electrical-consuming equipment—all with the engine turned off. The system helps to reduce fuel consumption, exhaust emissions and noise, and provides workers with a more comfortable work environment.[101]

GREEN IDEA: This year, the City of Toronto will begin operating the first hydraulic launch assist garbage truck in North America. As the class 8 truck comes to a stop in front of a house, the braking energy will be stored as pressure in the hydraulic system. This energy will then be used to move the truck to the next house. By using braking energy instead of diesel fuel to power the truck through its many stops, the system will help to reduce both fuel consumption and emissions.[102]

Clean Vehicle Resources

1. Transport Canada's ecoTechnology for Vehicles (eTV) program is testing the latest clean vehicle technologies. Results of the tests will help it develop regulations, codes and standards for the next generation of advanced vehicles. http://www.tc.gc.ca/programs/environment/etv/menu-eng.htm.
2. Transport Canada has studied the commercial viability of hybrid technology in urban garbage trucks (class 7 municipal garbage trucks). The study found that switching from conventional diesel to a hybrid refuse truck could save 5,000 litres of fuel and cut CO^2 emissions by 13 tonnes annually. http://www.tc.gc.ca/innovation/tdc/projects/road/i/5598.htm.

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98 Gizmag. *World's first hybrid refuse truck launched in Sweden*. April 8, 2008. http://www.gizmag.com/worlds-first-hybrid-refuse-truck-volvo-sweden/9131/.

99 City of Regina. http://www.regina.ca/AssetFactory.aspx?did=4453 and Leader-Post. *City of Regina shopping for a hybrid garbage truck*. February 11, 2010. http://www.leaderpost.com/technology/City+Regina+shopping+hybrid+garbage+truck/2542988/story.html.

100 Transport Canada. *Hybrid refuse truck feasibility study.* http://www.tc.gc.ca/innovation/tdc/summary/14400/14431e.htm.

101 Personal communication with Sarah Gingrich, Business Development & Improvement Analyst Fleet Services, City of Toronto. March 30, 2010.

102 Personal communication with Sarah Gingrich, Business Development & Improvement Analyst Fleet Services, City of Toronto. March 30, 2010.

Electric heavy-duty vehicles

Most of the all-electric or "plug-in" vehicles used in municipal fleets tend to be light-duty cars or trucks. Even though all-electric heavy-duty vehicles are available commercially, few municipalities in Canada have bought them or installed the plug-ins needed to recharge them.

One issue with providing infrastructure for these types of vehicles is how the electricity is generated. If it comes from clean, renewable sources (such as hydro or wind), overall emissions from transportation and from generating the electricity will decrease. In places where coal is used to create electricity, higher emissions will be the result. The Province of Alberta, for example, produced almost 60 per cent of its electricity from coal in 2008.[103]

The infrastructure needed to power all-electric vehicles will take time to install, with British Columbia set to be among the first Canadian province to have it in place, at least for light-duty vehicles.

The Electric Power Research Institute (EPRI) and more than 30 utilities, including BC Hydro, are working with the auto industry to prepare for installation of electrical infrastructure. This work includes doing a grid impact study to simulate the energy load required to recharge electric vehicles, reviewing building codes to require dedicated circuits for electric vehicle charging, as well as looking at safety issues. BC Hydro has written a set of guidelines for charging infrastructure as part of a project sponsored by Natural Resources Canada.[104]

GREEN IDEA: The Port of Los Angeles is testing battery-powered heavy-duty vehicles that can pull more than 27,000 kilograms of cargo. The prototype truck was built at a cost of $527,000 (USD), can reach speeds of up to 64 km/hour and has a range of about 97 kilometres. The truck can recharge in a few hours. In February 2009, the Los Angeles Harbor Commission opened a manufacturing plant that will produce all-electric heavy-duty trucks capable of hauling 30-ton shipping containers at the San Pedro Bay port complex. If the entire Port fleet is converted to electric-drive, at least two million short-range trips a year could be powered by electricity instead of diesel.[105]

GREEN IDEA: Electric trolley buses operate on major routes in the City of Vancouver, with one going as far as nearby Burnaby. The trolley buses get electricity from a network of overhead wires. In the fall of 2006, TransLink introduced a new generation of electric trolley buses to replace models built in the early 1980s. The new models feature low floors and are fully wheelchair accessible.[106]

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103 Government of Alberta. *Energy Facts*. http://www.energy.alberta.ca/News/984.asp.

104 BC Hydro. *Plug-in Vehicles*. http://www.bchydro.com/about/our_commitment/sustainability/plugin_vehicles.html and *Electric Vehicle Charging Infrastructure Deployment Guidelines British Columbia*, http://www.bchydro.com/etc/medialib/internet/documents/environment/EVcharging_infrastructure_guidelines09.Par.0001.File.EV%20Charging%20Infrastructure%20Guidelines-BC-Aug09.pdf.

105 The Port of Los Angeles. http://www.portoflosangeles.org/newsroom/2009_releases/news_022409_etruck.asp.

106 TransLink. http://www.translink.ca/.

Gasoline-electric hybrid vehicles

Like diesel-electric hybrids, gasoline-electric hybrid vehicles also combine an internal combustion engine with an electric motor, rechargeable batteries and a regenerative braking system that captures and reuses the energy lost during traditional vehicle braking.

Currently, most commercially available gasoline-electric vehicles tend to be in the car or light-duty classes, but some heavy-duty vehicles such as school and shuttle buses are now on the market. For example, New Flyer of Winnipeg, Manitoba, builds several different hybrid transit vehicles, including gasoline-electric hybrids.[107]

GREEN IDEA: The City of Toronto currently has five hybrid cube vans (Ford E450 models), making it the first municipality in Canada to use the gasoline-electric drive system developed by Azure Dynamics, a Canadian company. The city's parks, forestry and recreation, solid waste management services, and transportation services divisions use the vans in their day-to-day work.[108]

Fuel cell-powered buses

Transit buses that operate on hybridized hydrogen fuel cells can provide a 62 per cent[109] reduction in GHG emissions compared to their diesel equivalents. Transit buses powered by fuels offer not only great potential for lower environmental emissions, they are also quiet, which makes them ideal for use in urban areas.

At present, fuel cell transit buses are more expensive than conventional diesel buses. As new technologies are more broadly adopted, prices are expected to come down.

GREEN IDEA: During the 2010 Olympic and Paralympic Winter Games, a fleet of 20 fuel cell electric buses were run as part of Whistler's public transit fleet, making it the largest-ever fleet of fuel cell buses on the streets in a single location. Built by New Flyer Industries of Winnipeg, Manitoba, the buses use hydrogen fuel cells developed by Ballard Power Systems of Burnaby, B.C., hydrogen storage from Dynetek Industries of Calgary, Alta. and hydrogen fuel from Air Liquide Canada of Montreal, Que.[110] The buses are nearly twice as efficient as existing diesel buses, consuming 28 liters of hydrogen per 100 kilometers driven compared to 52 L/100 km for the diesels. Watch this video to learn more about how these fuel-cell powered buses reduce emissions while lasting 15 years with fewer maintenance costs and double the efficiency of diesel buses: http://www.youtube.com/watch?v=HvP1nSEB-po&feature=player_embedded

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107 New Flyer Industries. *Fourth Quarter 2009 Orders*. January 15, 2010. http://www.newflyer.com/index/news-app/story.75.

108 City of Toronto. http://wx.toronto.ca/inter/it/newsrel.nsf/bydate/166645D942E7FF7B852576CE005A4705.

109 http://www.poweringnow.ca/cars-and-buses/bc-transit/

110 National Research Council of Canada. *Fuel cells power Olympic transit*. http://www.nrc-cnrc.gc.ca/eng/dimensions/issue1/hydrogenhighway.html.

Section 5–Overcoming barriers

There are roughly 3,700 municipal governments in Canada, ranging in population from millions to just a few hundred. Regardless of size, almost all municipalities operate some type of municipal fleet and can benefit from knowing how to make those fleets greener.

Common barriers

The most common barrier faced by local governments in greening their municipal fleets is cost.

New and more efficient vehicles usually cost more than regular vehicles. The same can be true of some alternative fuels. The cost of adding infrastructure (such as advanced vehicle location systems, plug-ins for electric vehicles, etc.) or retrofitting or converting vehicles to conform to higher fuel efficiency standards can also be expensive at the outset.

On the other hand, it's a common misconception that being environmentally and socially responsible always costs more. Traditional economic models would likely reject a payback period of more than three years because they do not take into account the co-benefits of reducing GHG emissions. Using life cycle cost accounting to tally all the costs associated with green fleets, however, often shows that—over time—greener vehicles are more cost efficient to operate.

A final common barrier relates to the uncertainty that comes with new vehicle technologies or the use of alternative fuels. Since municipalities depend on their fleets to provide public services (garbage and recycling collection, emergency response, snow removal, and public transit), some may not wish to invest taxpayer funds in what may be viewed as "risky" new ventures.

Overcoming barriers

Adopting advanced technologies is just one way to green a municipal fleet. It's not the only way.

Many low-cost solutions exist that can reduce costs and emissions. Many of these are outlined in this guide. They include: fuel-efficient driver training, "right sizing" municipal fleets, installing filters or other emission control technologies and maximizing route efficiencies.

The benefits of such initiatives, such as lower operating and capital costs, fewer demands on physical asset management, and a healthier population and environment need to be taken into account when preparing a business case for making fleets greener.[111]

In addition, should carbon pricing become reality in Canada, the sale of carbon credits from GHG emission reductions could provide municipal governments with a new source of revenue.

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[111] Mirza, Saeed, *Danger Ahead: The Coming Collapse of Canada's Municipal Infrastructure,* prepared for the Federation of Canadian Municipalities, 2007. Cited in *Transportation Sector Research Final Report*, prepared by Marbek Resource Consultants Ltd. for FCM. http://www.sustainablecommunities.fcm.ca/files/Capacity_Building_Transportation/Transportation_Sector_EN.pdf.

Business Case Resources

1. *The Business Case for Cutting Greenhouse Gas Emissions from Municipal Operations*. Federation of Canadian Municipalities. http://www.sustainablecommunities.ca/files/Capacity_Building_-_PCP/PCP_Resources/PCP-Business-Case-e.pdf.

Financial Resources

Both the federal and provincial governments offer financial incentives to green municipal fleets. A few of these programs are listed below.

- The $8 billion Building Canada Fund (BCF) helps fund infrastructure projects including public transit. Information: http://www.buildingcanada-chantierscanada.gc.ca/funprog-progfin/target-viser/bcf-fcc/bcf-fcc-eng.html.
- As part of the BCF, between 2005 and 2014, the Gas Tax Fund will invest $13 billion (and $2 billion every year thereafter) to support municipal infrastructure including transportation infrastructure (such as rapid transit systems, transit buses and intelligent transportation system technologies). Information: http://www.infc.gc.ca/ip-pi/gtf-fte/gtf-fte-eng.html.
- The $5.2 billion Canada Strategic Infrastructure Fund invests in large-scale projects, including public transportation infrastructure in major urban centres. Information: http://www.infc.gc.ca/ip-pi/csif-fcis/csif-fcis-eng.html.
- The $1.5 billion (2008-2017) ecoENERGY for Biofuels program supports biofuel production in Canada. Its goals are to attain volume targets of two billion litres of renewable alternatives to gasoline and 500 million litres of renewable alternatives to diesel. The program hopes to speed up the commercialization of new biofuel technologies, which could lower the price for biofuels. Information: http://oee.nrcan.gc.ca/transportation/ecoenergy-biofuels/index.cfm.
- The Province of Ontario makes two cents/litre of its provincial gas tax available to municipalities for public transit. Information: http://www.mei.gov.on.ca/en/infrastructure/sectors/?page=transportation.
- The Federation of Canadian Municipalities' Green Municipal Fund offers grants of up to $400,000 and low-interest loans of up to $4 million to municipal governments that wish to study and/or invest in capital projects, including transportation. Information: http://www.sustainablecommunities.fcm.ca/GMF/.
- For a more complete listing of funding programs available for public transit, see the Canadian Urban Transit Association's (CUTA) *Federal, Provincial & Territorial Funding of Public Transit in Canada: A Compendium*. February 2009. http://www.cutaactu.ca/sites/cutaactu.ca/files/Federal%20Provincial%20Territorial%20Funding%20of%20Public%20Transit%20in%20Canada.pdf.
- Conserve Nova Scotia – Incentives for Heavy-Duty Hybrid Trucks http://www.conservens.ca/on-the-road/incentives-hybrid-trucks.asp
- Municipalities may also benefit from provincial or utility incentives to produce renewable electricity. This electricity can then be used to power electric vehicles. The federal government's ecoENERGY for Renewable Power program, for example, will invest $1.48 billion to increase Canada's supply of electricity from renewable sources. http://ecoaction.gc.ca/ecoenergy-ecoenergie/power-electricite/index-eng.cfm.

Life cycle cost accounting

In making the business case for greener fleets, municipalities must take into account the full life cycle costs of such investments. Unlike typical cost accounting, life cycle cost accounting—also known as total cost or triple-bottom-line accounting—considers a broader range of factors, such as:

- What products are made from
- Where products come from
- Who makes them
- How they will eventually be disposed of, and
- Whether the purchase needs to be made at all.

In other words, life cycle accounting includes all the economic, environmental and social costs linked to a product or service over *its entire lifetime*.

Factors involved in lifecycle cost accounting can be direct or indirect:

Direct factors	Indirect factors
• Operational and capital costs (such as purchase price and yearly costs to operate equipment) • Costs to dispose of or decommission equipment (such as waste disposal or recycling) • Insurance and liability costs	• Health (the medical costs associated with poor air quality) • Environmental (the impact of GHG emissions or other air and water contaminants on the local or regional environment) • Social (worker safety, community safety) • Ethical (showing municipal leadership; "doing the right thing")

Life Cycle Cost Resources

1. The Sustainability Purchasing Network's *Applying Total Cost of Ownership to Sustainability Purchasing* is a workbook that reviews how to make purchases more cost-effective and sustainable. http://www.buysmartbc.com/UserFiles/File/TCO%20Workbook.pdf.
2. E3 Fleet has developed a life cycle analysis tool especially for fleets. For information, contact their transportation analyst at info@E3fleet.com or http://www.e3fleet.com/.

Section 6–General resources for municipalities

Throughout this guide, we have provided you with lists of resources on specific topics. This final section provides you with more general resources on fleet management.

Natural Resources Canada. *FleetSmart*. http://fleetsmart.nrcan.gc.ca/index.cfm. The website gives you access to free workshops and booklets on energy-efficient vehicles as well as vehicle and business practices that can reduce fleet operating costs and improve productivity. It also helps fleet managers choose the green features of heavy-duty vehicles to meet their needs.

Fleet Challenge Ontario. http://www.fleetchallenge.ca/. Provides several resources to help fleet operators reduce fuel consumption, operating costs and emissions.

E3 Fleet: Energy Environment Excellence. http://www.e3fleet.com/. E3 Fleet was developed by fleet managers for fleet managers. It offers services and information to help fleet operators increase fuel efficiency and to reduce costs and emissions.

The City of Toronto, in partnership with the City of Hamilton, Fleet Challenge Ontario, the Ontario Ministry of Transportation and Centennial College annually hosts a *Green Fleet Expo* where fleet managers can learn about green vehicles and equipment. It includes hands-on testing of various vehicles and equipment as well as educational presentations. http://www.toronto.ca/fleet/expo.htm.

Clean Air Partnership: Actions being taken by GTA-CAC Municipalities to Reduce Emissions from Municipal Vehicles (September 2007)
http://www.cleanairpartnership.org/pdf/gta_cac_municipal_vehicles.pdf

Green Fleets BC
http://www.greenfleetsbc.com/

Canadian Association of Fleet Supervisors
http://www.cafs.ca/

North American Fleet Management Association
http://www.nafa.org/Template.cfm?Section=Ontario

Clean Air Partnership Fleet Emission Tool (web-based tool that could be used by fleet managers/operators to estimate the energy consumption of their fleet and to identify opportunities to enhance energy efficiency of their operations.
http://www.cleanairpartnership.org/fleet_emissions_tool

ICLEI Green Your Fleet
http://www.morpc.org/pdf/Green_Your_Fleet.pdf

Conclusion

Municipalities across Canada have the potential to reduce GHG and CAC emissions by greening their heavy duty diesel fleets. Increasingly, they are acting to improve efficiency, reduce exhaust emissions, switch to cleaner fuels, and reduce the number and size of heavy-duty diesel vehicles as well as the length and frequency of trips.

Because each municipal fleet is unique, it is important to understand where the most potential lies to reduce emissions. In creating any municipal green fleet plan, it is essential to consider the heavy-duty diesel fleet. Information about both vehicle technologies and tactics can be applied to heavy-duty diesel fleets. As well, a wealth of resources is available to support decision-making processes and recommend steps that will help in the planning stages leading to a greener municipal fleet. Municipalities that have a process in place will meet fewer roadblocks in decision-making and implementation of their plans.

Decision-makers, fleet managers, their networks and associations, and stakeholders in the fleet industry can all benefit from open dialogue about what is working and what is not working. By effectively measuring the impacts of various actions to reduce emissions, everyone will benefit further. This approach will also help all decision-makers evaluate the best ways to allocate their limited resources.

We hope that this guide will serve as an inspiration that spurs further investigation and discussion on ways to achieve greener fleets within your municipality.

Glossary

Biodiesel: A vegetable oil- or animal fat-based diesel fuel, biodiesel is typically made by combining lipids (such as vegetable oil, animal fat (tallow)) with an alcohol. It is meant to be used in standard diesel engines and is thus distinct from the vegetable and waste oils used to fuel *converted* diesel engines. Biodiesel can be used alone or blended with petrodiesel.

Biofuels: A wide range of fuels that are in some way derived from biomass, including solid biomass, liquid fuels and various biogases.

Compressed natural gas (CNG): Natural gas stored in high-pressure containers and used mainly as an alternative fuel for internal combustion engines.

Criteria Air Contaminant (CAC): A group of air pollutants that cause smog, acid rain and other health hazards. CACs include emissions of sulfur oxides (SOx), nitrogen oxides (NOx), particulate matter (PM), carbon monoxide (CO), lead (Pb), and ground-level ozone (O3). [1] CACs are emitted from many sources in industry, mining, transportation, electricity generation and agriculture. In most cases they are produced by the combustion of fossil fuels or industrial processes.

Diesel oxidation catalyst (DOC): A type of filter attached to an existing or replacement muffler to reduce emissions and particulate matter. In the presence of the catalyst, carbon monoxide and hydrocarbons are removed from the exhaust gas stream as they react with oxygen.

Ethanol: Ethanol, or ethyl alcohol, is made principally from corn and wheat. Cellulosic ethanol can be made from a wider range of materials including leftover agricultural, forestry and organic wastes, including cereal straws, corn stalks, organic municipal solid waste, sawdust and paper pulp. These feedstocks can be combined in cellulosic ethanol.

Geographic information system (GIS): Any system that captures, stores, analyzes, manages, and presents data that are then linked to location. GIS includes mapping software and its application to remote sensing, land surveying, aerial photography, mathematics, photogrammetry, geography, and other tools that can be implemented with GIS software. Usually used in combination with GPS (*see below*).

Global positioning system (GPS): A network of Earth-orbiting satellites that allows people with ground receivers to pinpoint geographic locations. Its accuracy is anywhere from 100 to 10 meters, with most equipment.

Greenhouse gas (GHG): Gas in an atmosphere that absorbs and emits radiation within the thermal infrared range. This process is the fundamental cause of the greenhouse effect.[1] The main greenhouse gases in the Earth's atmosphere are water vapor, carbon dioxide, methane, nitrous oxide, and ozone.

Homogeneous charge compression ignition (HCCI): HCCI is a form of internal combustion in which fuel and air are mixed in the combustion chamber, similar to a spark-ignited gasoline engine, but with a high proportion of air to fuel. As the engine's piston reaches its highest point on the compression stroke, the air-fuel mixture auto-ignites (meaning that complete combustion occurs without the aid of a sparkplug) from the compression heat, much like a diesel engine.

Hybrid vehicle: Hybrid vehicles combine an internal combustion engine (gasoline or diesel) with an electric motor, rechargeable batteries and a regenerative braking system that captures and reuses the energy usually lost during traditional vehicle braking.

Hydrogen fuel cell: A hydrogen fuel cell operates like a battery with two electrodes (an anode and a cathode) separated by a membrane. Specifically, a fuel cell combines hydrogen and oxygen to produce electricity, heat and water. This kind of cell does not need to be recharged.

Intelligent transportation system (ITS): A catch-all term to describe the addition of information and communications technology to transportation systems and vehicles to manage such factors as vehicle locations, loads, schedules and fuel consumption.

Life cycle accounting (also known as full-cost or triple-bottom-line accounting): An accounting method that considers the total cost of products and services, including purchase price, operating costs, lifespan and disposal costs. It also considers the environmental, health and social costs involved in using products and services.

Liquefied petroleum gas (LPG): Used for space heating and vehicles, the most common variety of LPG is a mixture of propane and butane.

P-series fuel: Clear liquid fuels, between 89 and 93 octane, designed to be used in flex-fuel vehicles. P-series fuels are a blend of 35 per cent natural gas liquids, 45 per cent ethanol, and 25 per cent biomass-derived co-solvent.