SUBJECT: Green Fleet Implementation Plan Phase 2, 2009-2011 (PW03147c) - (City Wide)

RECOMMENDATION:

(a) That staff be authorized to continue the work begun in the first phase of the Green Fleet Implementation Plan 2006-2008 with the objectives of reducing emissions of greenhouse gases and reducing fuel consumption in the Central Fleet, and maintain Hamilton’s place as a leading Green Fleet, as per Appendix A to Report PW03147c;

(b) That the incremental cost for the purchase of hybrid, electric and other “green technology” vehicles be funded from the Fleet Vehicle and Equipment Replacement Reserve fund, and that an increase in contributions from user operating budgets of 3% over the previous year’s contributions be considered as part of the annual budget process for 2010 and 2011;

(c) That all of City operating groups prepare plans to reduce fuel consumption by 5% as part of the 2010 budget process.

EXECUTIVE SUMMARY:

Since the initial Green Fleet Implementation Plan was approved by Council in 2005, Hamilton has been recognized as a leader in the use of advanced vehicle technology that reduces fuel consumption and greenhouse gas emissions that cause climate change. It has the second-largest fleet of hybrid and other clean and efficient vehicles in Ontario and actively participates in studying and promoting new technology.
Hamilton’s hybrid fleet has grown to 135 vehicles and has helped to convince vehicle manufacturers that the hybrid market is worth pursuing aggressively. Other municipalities have followed Hamilton’s lead. Our partnership with many of them, in particular the City of Toronto through showcase events like the Green Fleet Expo has demonstrated our progress.

Phase 2 of the Green Fleet Implementation Plan covers the period 2009-2011. It examines a much larger number of technologies and best practices that can improve our fleet’s fuel efficiency and reduce exhaust emissions. Some have only a small impact while others, such as hybrid heavy-duty trucks, may improve fuel efficiency by as much as 30% on individual vehicles.

Our objectives are to continue to improve fuel efficiency, reduce emissions of greenhouse gases to meet the target in the Corporate Strategic Plan of 2% per kilometre travelled per year, and maintain Hamilton’s place as a leading Green Fleet. The scope of this plan is the Central Fleet, but the other City fleets (Transit, Fire and EMS and Police) are making excellent progress using this plan’s tactics and others suitable to their unique operations.

Our strategies, reduce petroleum fuel used by City fleet vehicles, and promote this message to the market, are influencing the development of more vehicle models that make the strategy succeed. Fleet management itself has moved to make fuel efficiency and environmental impact a higher priority.

The outcomes will include better capability to manage the Peak Oil situation and the effects of climate change even in times of financial constraints. Our image as a city that is innovative and resourceful in its approach to the environment is enhanced by initiatives like the Green Fleet Implementation Plan.

**BACKGROUND:**

The information/recommendations contained within this report have City wide implications.

As Table 1 shows, a significant commitment to having a green fleet has already been made by the City of Hamilton.

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Number of Units in Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smart ForTwo – micro car</td>
<td>2</td>
</tr>
<tr>
<td>Honda Civic – hybrid car</td>
<td>2</td>
</tr>
<tr>
<td>Toyota Prius – hybrid car</td>
<td>6</td>
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<tr>
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<td>Saturn Vue – hybrid car</td>
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<tr>
<td>Vehicles with &quot;idle-free&quot; interior heaters</td>
<td>6</td>
</tr>
</tbody>
</table>
Table 1 - Continued

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<td>Ford E250 – natural gas van</td>
<td>5</td>
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<td>Ford F150 – natural gas pickup</td>
<td>1</td>
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</tr>
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<td><strong>Green Fleet Percentage of overall fleet</strong></td>
<td><strong>23</strong></td>
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Appendix B to this report describes ten initiatives in addition to those listed in Table 1 undertaken since the Green Fleet Implementation Plan began. All of these demonstrate the high priority that fleet management has been giving to fuel conservation and emission reductions. The outcomes include better capability to manage the Peak Oil situation and the effects of climate change even in times of financial constraints. Our image as a city that is innovative and resourceful in its management of the environment is enhanced by initiatives like the Green Fleet Implementation Plan.

Table 2 shows the results from Phase One of the Green Fleet Implementation Plan.

Table 2
Results from Phase One of Hamilton’s Green Fleet Implementation Plan 2006-2008

<table>
<thead>
<tr>
<th>Action</th>
<th>Target Result</th>
<th>Actual Result</th>
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<tr>
<td>Increase use of hybrids</td>
<td>46 new vehicles</td>
<td>105 new vehicles</td>
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<td>Hybrid GHG emissions</td>
<td>Reduced 111 tonnes</td>
<td>Reduced 210 tonnes</td>
</tr>
<tr>
<td>Use biodiesel</td>
<td>21.0 million litres at 10%</td>
<td>2.8 million litres at 5%</td>
</tr>
<tr>
<td>Biodiesel GHG emissions</td>
<td>Reduced 3,892 tonnes</td>
<td>Reduced 336 tonnes</td>
</tr>
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The Central Fleet has reduced greenhouse gas emissions by 546 metric tonnes over the three-year timeframe of Phase One. This is equivalent to reducing the fleet by 45 vehicles. This has been calculated from those sources where accurate measurements can be taken, namely fuel used in hybrid vehicles and the amount of biodiesel fuel consumed. Many other tactics such as reduced idling and improved maintenance and operating practices have not been measured and reported, because estimates have a wide margin of error.

Following direction from the Senior Management Team, the use of hybrid vehicles accelerated beyond the initial plan and GHG emission reductions were proportionately better. The use of biodiesel was reduced for a number of reasons. Market conditions in 2006 made the price unaffordable. When biodiesel was introduced in 2007, it was only available in a 5% blend instead of the 10% blend anticipated in the original plan. In addition, Central Fleet had to restrict the use of biodiesel to the Wentworth Street North location, as that is the only location besides the Transit Division yard that can receive the minimum 50,000 litre loads that were a condition of the supplier. Our contractual
obligations with fuel suppliers also restricted our use of biodiesel to our summer contract only.

**ANALYSIS/RATIONALE:**

There are a number of drivers for creating Phase 2 of the Green Fleet Implementation Plan. The key drivers are:

1) The City of Hamilton Strategic Plan includes Key Activity 6.2.1, Update the Green Fleet Plan by 2009 with an objective of lowering greenhouse gas (GHG) emissions per kilometre travelled by 2% per year.

2) The price of crude oil increased more than 300% between 2006 and mid-2008. Although that spike in price was reversed in the last half of 2008, the effect could have created an enormous budget pressure. The diesel fuel budget for Central Fleet in 2008 was overspent by 21% or $832,000, because of the escalated prices. Gasoline, which has been the main focus of the Green Fleet Plan, was overspent by less than 2% or $32,000.

3) The volatility in crude oil pricing, concerns about climate change, and the impending Peak Oil situation have all contributed to accelerating the development of more fuel-efficient and cleaner vehicles, especially hybrid and electric vehicles. The United States has legislated large improvements in fuel economy for new cars by 2012 that is also driving manufacturers to change their product line-up.

These drivers are compelling reasons to continue to build on the success of the Green Fleet Implementation Plan for the Central Fleet and for the user groups to prepare plans to reduce fuel consumption by 5% as part of the 2010 budget process.

Appendix A to this report is a list of twenty-seven tactics to reduce fuel consumption and greenhouse gas emissions detailed in a Natural Resources Canada program called FLEETtool.ca. Taken collectively, more than a 5% reduction in fuel consumption can be achieved. However there are limitations on the use of every tactic in each operating group. Individual plans will select those tactics that are most suitable for their unique operations.

**ALTERNATIVES FOR CONSIDERATION:**

The Green Fleet Implementation Plan does not offer a recommendation to increase the use of natural gas as an alternative to gasoline, diesel or biodiesel fuels. The City currently operates more than 100 vehicles on natural gas, mostly Transit buses, but ice resurfacer are the only ones that have firm plans to be replaced with new natural gas vehicles.

Natural gas vehicles (NGVs) were well supported in the market in the 1990s and were the most successful alternatives to conventionally-fuelled vehicles. There were many convenient places to fill up with natural gas and factory-built and warranted vehicles were offered by Chrysler, Ford and General Motors.

Natural gas filling stations have now almost disappeared in the Hamilton area and there have not been any factory-built and warranted NGVs available in Canada for many years. The introduction of hybrid gas-electric vehicles in 2000 created an alternative to
natural gas that did not require a different fuel system or any change to a driver's routine stops for fuel. This is likely the most important factor in the decline of interest in NGVs. The use of after-market conversions that enable the use of natural gas for light-duty vehicles is not recommended as they would be completely dependent on the City's two natural gas compressors for fuel. The cost of maintaining these refuelling compressor stations has been increasing and they are planned for decommission in 2015.

The Cummins-Westport natural gas engine for heavy trucks and buses is still available and has been considered by staff as an alternative. No recommendation is being made as the situation with our two natural gas compressor stations has been explained above and the reliability of our natural gas buses has been lower than diesel buses. The Transit Division has acquired diesel-electric hybrid buses recently and is evaluating their cost and reliability. Council has approved three hybrid waste collection trucks (Report PW08106) that will use a hydraulic launch assist system.

**FINANCIAL/STAFFING/LEGAL IMPLICATIONS:**

**Financial:** The Fleet Vehicle and Equipment Reserve Fund receives contributions from user operating budgets to pay for the cost of replacement vehicles. These contributions normally increase by 3% each year to cover the cost of inflation. It is being recommended that the contributions increase in 2010 and 2011 to pay for the additional capital cost of hybrid, electric and other green technology available on vehicles and equipment. The estimated additional cost for hybrid vehicles is $170,000 in this period.

Biodiesel fuel purchases in 2007 and 2008 did not have any budget impact.

Reduced engine idling could have a significant impact on operating budgets for fuel. We have not been successful in obtaining accurate measurements of idling without the addition of expensive equipment such as automated vehicle location systems and therefore cannot offer an estimate of fuel savings at this time.

**Staffing:** Additional training for operators and fleet technicians is required for many of the fuel reduction tactics covered in the Green Fleet Implementation Plan. There are no requirements for changes in complement expected.

**Legal:** There are no legal implications.

**POLICIES AFFECTING PROPOSAL:**

City of Hamilton Strategic Plan 2008-2011

Key Activity 6.2.1

“Update the Green Fleet Plan by 2009 with an objective of lowering greenhouse gas (GHG) emissions per kilometre travelled by 2% per year.”

Public Works Strategic Plan vision: “To be recognized as the centre of environmental and innovative excellence in Canada”.

Corporate Air Quality & Climate Change Strategic Plan
RELEVANT CONSULTATION:

The Central Fleet Advisory Committee includes the following members:

- Animal Control: Calum Burnett
- Central Fleet: Deb Manningham, Tom Kagianis, Aldo Mostacci, Gary McKechnie, Christinna Robins, Chris Hill (Chair)
- Development & Engineering: Mike Becke
- Community Facilities: Peter Paweska
- Finance: Craig Webb
- Forestry: John Taylor
- Hamilton Fire/EMS: Robert Kay
- Hamilton Police: Dan Bowman
- Information Services: Ana Rodic
- Operations & Maintenance: Al Fletcher
- Parking Enforcement: Paul Buckle
- Planning & Development: Nick Anastasopoulos
- Purchasing: Donna Drozdz, Lesley Parker-Bowen
- Risk Management: Michael Hill
- Transit: Doug Murray
- Waste: Colin Vidler
- Water & Wastewater: Bert Posedowski, Ross Bint

The members of Clean Air Hamilton reviewed the plan and provided comments.

Natural Resources Canada gave permission to reprint the material from FLEETtool.ca.

GO Transit operations have consented to the use of biodiesel in their buses that refuel at City of Hamilton facilities.

CITY STRATEGIC COMMITMENT:

By evaluating the “Triple Bottom Line”, (community, environment, economic implications) we can make choices that create value across all three bottom lines, moving us closer to our vision for a sustainable community, and Provincial interests.

Community Well-Being is enhanced. ☑ Yes ☐ No
The City’s image as an innovative and resourceful fleet operator is enhanced by the Green Fleet Implementation Plan.

Environmental Well-Being is enhanced. ☑ Yes ☐ No
Greenhouse gas emissions and air pollution from City vehicles is reduced.

Economic Well-Being is enhanced. ☑ Yes ☐ No
By reducing fuel consumption by 5%, the City has better control over its operating budget and reduces exposure to commodity price fluctuations.

Does the option you are recommending create value across all three bottom lines? ☑ Yes ☐ No

Do the options you are recommending make Hamilton a City of choice for high performance public servants? ☑ Yes ☐ No
The City demonstrates commitment to action in both the Corporate Strategic Plan and the Public Works Strategic Plan by implementing the tactics recommended in this report.
Recommended Actions for Phase 2 of the Green Fleet Implementation Plan Using FLEETtool.ca Tactics

Group 1 – Aerodynamics
Tactic 1. Aerodynamic tractors
Tactic 2. Gap Closing Devices
Tactic 3. Cab roof deflectors
Tactic 4. Trailer side skirts
Tactic 5. Rear boat-tails
Tactic 6. Roof racks
None of the above are applicable to Central Fleet.

Group 2 – Components
Tactic 7 - Air conditioners will be maintained to prevent escape of refrigerant, which is a greenhouse gas, to the atmosphere.

Tactic 8 - Auxiliary power units
An APU pilot test for Police vehicles and ambulances has been initiated by the Ontario Government and implemented by Fleet Challenge Ontario, a private firm that has worked with Central Fleet and the City of Toronto Fleet Services Division on several fleet efficiency projects. Both our Police and EMS groups have been eager to participate in order to promote energy conservation.

Further introduction of auxiliary batteries appears to be warranted by the fuel savings observed on our initial six vehicles.

Tactic 9 - The use of block heaters on fleet vehicles parked outside will be reviewed with users, the Office of Energy Initiatives and the Corporate Buildings section.

Tactic 10 - The use of on-board computers to monitor fuel consumption will be initially restricted to those vehicles that have them as standard original equipment. The Vancouver study will be reviewed to identify opportunities for trial of some types of “eco-meters”. Operator training will include instructions on how to use them to improve fuel efficiency.

Tactic 11 – Roof racks are not common on our vehicles and as they are permanently mounted a measure to remove them would not be practical.

Tactic 12 – Tires are being investigated to find suitable designs that reduce fuel consumption. Tires have a larger impact on long-haul highway transportation than in City operations, so changing tire specifications may not have a payback to the City.
Group 3 – Driver Behaviour

Tactic 13 – Aggressive Driving is addressed in our Professional Driver Improvement Course, a service offered by Central Fleet. Denver’s “Driving Change” program will be presented to Clean Air Hamilton and Fleet Challenge Ontario to assess the possibility of duplicating the program in Hamilton.

Tactic 14 – Cruise Control will be restricted to those vehicles that have them as standard original equipment. Hamilton’s urban roads do not have high enough speeds or long enough distances between traffic signals to make cruise control practical.

Tactic 15 – Idling Time, Light-Duty Vehicles

This issue is addressed in our driver training program, and is regulated by both our Corporate Policy and by a City by-law. The increasing use of hybrid vehicles will continue to reduce idling, as these engines are designed to shut down when the vehicle is stopped. Exceptions will occur when the air conditioner or defroster is turned on, or when the battery is low.

As described under Tactic 8 above, Hamilton Emergency Services and Hamilton Police Services are participating in the Fleet Challenge Ontario Police & EMS Vehicle Idling Reduction Demonstration Project (PEMS).

Tactic 16 – Idling Time, Heavy-Duty Vehicles

Tactic 17 – Speed

These issues are addressed as the engine control module (ECM) in about 248 heavy trucks in our fleet has been re-set to comply with Ontario’s speed-limiter law. Trucks are limited to 105 km/h when driving and 15 minutes maximum idling when stopped. Users will be consulted if a lower idling time can be implemented.

Tactic 18 – Winter Driving is part of our regular Professional Driver Improvement Course offered by Central Fleet.

Group 4 – Fleet Management

Tactic 19 – Driver Training is focused largely on safety and adherence to regulations for commercial vehicles. In 2008 Central Fleet introduced new training using the “Fleet Smart” material from Natural Resources Canada, which includes fuel conservation measures.

Tactic 20 – Purchasing decisions reflect the recommendations in this decision. Following the approval of Phase One of the Green Fleet Implementation Plan in 2005, the Senior Management Team directed all users of light-duty fleet vehicles to specify hybrid vehicles whenever a replacement was ordered. This has resulted in the hybrid vehicle fleet growing from 15 units in 2005 to 135 units in 2009.

The use of minicars such as the Smart Fortwo has brought favourable attention to the City. There is one car in Central Fleet and another in the Police fleet. In 2008, the standard engine in this car was changed from a diesel to a gasoline engine requiring premium-grade unleaded fuel. This reduces our ability to track
fuel consumption as we do this through the automated fuel pump system at City bulk fuel stations, and these stations do not have additional storage tanks to provide premium-grade gasoline. Therefore the acquisition of more Smart cars is not being pursued.

Tactic 21 – Transportation Demand Management is addressed in Hamilton’s Transportation Master Plan. There are commercial carsharing services available in Toronto but not Hamilton. This will be encouraged through our contracts for car rentals.

Group 5 – Fuels and Technology

Tactic 22 – Alternative Fuels

Hamilton has long experience with alternative fuels, including the use of natural gas for buses and other city vehicles. Biodiesel and ethanol are in use and have created no operating problems. For the 2009 to 2011 timeframe of this report, hydrogen will not be commercially available. Ethanol for gasoline-powered vehicles and biodiesel for diesel engines will continue to be supplied through the City’s bulk fuel storage facilities. Propane will continue to be used for some indoor equipment and natural gas for the remainder of indoor equipment plus the remaining HSR buses in service. The continued use of natural gas for buses is being addressed in a separate report. Natural gas is not a sustainable option for the balance of Central Fleet vehicles.

Electric vehicles are the focus of several automotive manufacturers’ research efforts and Hamilton is actively involved in efforts to accelerate the implementation of EVs where practical and affordable.

Tactic 23 – Hybrid light-duty vehicles

Hamilton has used hybrid light-duty vehicles for 10 years. It was the leading Canadian municipal hybrid owner for many years and maintains a prominent position in the front rank of hybrid fleet users. The light-duty hybrid fleet would expand faster if any reasonably-priced pickup trucks were available. The pickup product on offer for the 2009 model year is considered too expensive and is not being produced as a mass-market vehicle like the Ford Escape. Central Fleet will continue to replace conventional vehicles with hybrids unless a business case to not use a hybrid is approved by the General Manager of the department concerned.

Tactic 24 – Hybrid heavy-duty vehicles

Council has approved the purchase of up to three hydraulic launch-assisted hybrid waste collection trucks to implement the multi-residential Green Cart program (Report PW08106). Central Fleet is proposing one diesel-electric aerial truck for Forestry Operations during Phase 2 of the Green Fleet Implementation Plan. As pricing has not been confirmed, no commitment has been made at this time.

The Transit Division is receiving 18 more diesel-electric hybrid buses in 2009.

Group 6 – Fleet Maintenance
Tactic 25 – Air Conditioner Maintenance will be performed so as to prevent the release of air conditioning refrigerant to the atmosphere.

Tactic 26 – Lubricants will be investigated to see if additional fuel savings are possible through the use of lower viscosity oils. Hydraulic fluids that are refined from non-petroleum sources are being used now, to reduce the impact of spills on the ground, waterfowl and other aquatic life. Recycled engine oil is the standard for oil changes in Central Fleet.

Tactic 27 – Tire maintenance routines are being investigated to maximize tire life and reduce additional fuel use caused by under-inflated tires and mis-aligned wheels. Nitrogen as a substitute for ordinary compressed air is not recommended.
Appendix B

Green Fleet Implementation Plan, Phase 2
April 2009

Prepared by the Central Fleet Advisory Committee, City of Hamilton

Acknowledgements

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We also thank the members of Clean Air Hamilton for their review of the plan and their helpful comments, and Natural Resources Canada for the material on FLEETtool.ca.

Authors

Chris Hill, Manager Central Fleet, Public Works Department
John Mater, Director, Energy, Fleet & Facilities Division, Public Works Department

Reference


For more information

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Public Works Department, City of Hamilton
330 Wentworth Street North, Hamilton, Ontario L8L 5W2 Canada
www.hamilton.ca/fleet

Manager Central Fleet 905-546-2424 ext. 4593
City of Hamilton 905-546-2489
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1. Executive Summary

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### Table 1

<table>
<thead>
<tr>
<th>Action</th>
<th>2009 Result</th>
<th>2010 Result</th>
<th>2011 Result</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hybrid GHG improvement</td>
<td>140 tonnes</td>
<td>151 tonnes</td>
<td>163 tonnes</td>
<td>454 tonnes</td>
</tr>
<tr>
<td>Biodiesel GHG improvement</td>
<td>168 tonnes</td>
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<td>168 tonnes</td>
<td>504 tonnes</td>
</tr>
</tbody>
</table>
2. Situation – Factors Driving the Green Fleet Plan

Indicator Lights on the Dashboard – mid-year 2008

- Crude oil reaches $147 per barrel – yellow light
- Global energy consumption up – yellow light
- US vehicle miles traveled declines for sixth straight month – yellow light
- Car sales exceed truck sales for third month in a row – yellow light
- New hybrid car sales exceed 3% - green light
- California gasoline consumption declining – green light
- Canadian gasoline use down 7% in 2nd quarter – yellow light

These are all indicators that things were not what they used to be. Then the global economic downturn began in September 2008. By early 2009, some indicators began changing colour.

- Electric vehicles sparkle at Detroit Auto Show – green light
- Crude oil falls to $31 per barrel – green light
- US light duty vehicle sales down 18% for 2008 – yellow light

“Today, the auto industry faces a greater challenge: to create technologies that address global climate change, energy sustainability and energy security. Our global society may never have a better opportunity to make a serious effort to address that challenge. The fusion of a pocketbook issue (fuel prices) with concern about the environment (greenhouse gas reduction) and energy security has created a powerful junction of policy and market forces.” - Edward Cohen, vice president of government relations at American Honda Motor Co. In., writing in Automotive News, August 11, 2008

The City of Hamilton’s Commitment

In 2008 Council approved the City of Hamilton Strategic Plan 2008-2011. A commitment to prepare this document was made in Key Activity 6.2.1:

“Update the Green Fleet Plan by 2009 with an objective of lowering greenhouse gas (GHG) emissions per kilometer traveled by 2% per year.”
Table 2
Current Green Fleet April 2009
Includes Central Fleet, Transit, Police, Fire and Emergency Services

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How fuel-efficient are they?
Our hybrid cars are the most fuel-efficient vehicles in the fleet. Of the 50 most fuel-efficient vehicles in the Central fleet, 45 are hybrids. The others include a Smart car (diesel), Sprinter van (diesel), and three gas-powered cars.

Table 3
Results from Phase One of Hamilton’s Green Fleet Implementation Plan 2006-2008

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</tbody>
</table>
The Central Fleet has reduced greenhouse gas emissions by 546 metric tonnes over the three-year timeframe of Phase One, the equivalent of reducing the fleet by 45 vehicles or 5%. This has been calculated from those sources where accurate measurements can be taken, namely fuel used in hybrid vehicles and the amount of biodiesel fuel consumed. Many other tactics such as reduced idling and improved maintenance and operating practices have not been measured and reported, because estimates have a wide margin of error.

Following direction from the Senior Management Team, the use of hybrid vehicles accelerated beyond the initial plan and GHG emission reductions were proportionately better. The use of biodiesel was reduced for a number of reasons. Market conditions in 2006 made the price unaffordable. When biodiesel was introduced in 2007, it was only available in a 5% blend instead of the 10% blend anticipated in the original plan. In addition, Central Fleet had to restrict the use of biodiesel to the Wentworth Street North location, as that is the only location besides the Transit Division yard that can receive the minimum 50,000 litre loads that were a condition of the supplier. Our contractual obligations with fuel suppliers also restricted our use of biodiesel to our summer contract only.

**Other “Green Fleet” Initiatives**

Hamilton is in the front rank of public sector fleets that are undertaking “green fleet” initiatives. Some of the other notable fleets with approved plans are shown below.

**City of Toronto’s Green Fleet Plan 2008-2011**

Toronto’s plan covers 4,700 vehicles, similar mix to Hamilton (light, medium and heavy trucks and equipment). Phase 1 of their Green Fleet Plan reduced GHGs by 5,088 tonnes, over four years 2004-2007. Phase 2 was introduced in January 2008 with the following targets:

- Replacing a minimum of 520 vehicles with green vehicles
- Pilot testing hybrid heavy trucks and hydrogen-powered vehicles
- Promoting the Idle-Free campaign for City staff

**Province of Ontario’s Green Plan 2008-2012**

- The Province has 6,500 vehicles, mostly light vehicles and pickups, in the government fleet
- 400 hybrids acquired by end of 2008
- Optimize technology: hybrids, telematics, hydrogen, electric vehicles
- Goal is 10% reduction in GHGs by 2012

**British Columbia’s Climate Action Plan**

- Goal is to begin reducing overall GHGs by 2012 and be 15% or more below 2007 levels by 2016.
- The Province has 3,000 light vehicles, 55% are pickups
- 20% of fleet will be replaced with hybrids by 2011
### Greater Toronto Area Municipalities Using Green Fleet Tactics

Source: Clean Air Partnership September 2007

<table>
<thead>
<tr>
<th>Location</th>
<th>Idling Policy</th>
<th>Operator Training</th>
<th>Hybrids</th>
<th>Biodiesel</th>
<th>Other fuels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burlington</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Caledon</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Halton</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Hamilton</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Markham</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Mississauga</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Oakville</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Oshawa</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Peel</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Pickering</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Richmond Hill</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toronto</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Vaughan</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Whitby</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

By 2020, plug-in hybrids and battery powered vehicles will be commonplace.

New, higher fuel-economy regulations will require this. “We are not going to meet these standards by magically cloning the internal combustion engine that does double what it does today. We made a huge investment in the Chevrolet Volt because we believe it is a huge technology that is going to be in the mainstream.” – Jon Lauckner, General Motors vice president speaking at the Automotive News World Congress in Detroit, January 2009.

### 3. Objectives

1. Reduce emissions of greenhouse gases to meet the targets in the City’s Strategic Plan.
2. Reduce fuel use and improve litres/100 km results.
3. Maintain Hamilton’s place as a leading Green Fleet.
Scope of Phase 2 of the Green Fleet Implementation Plan 2009-2011

This phase of the Green Fleet Implementation Plan is focused on the City of Hamilton's Central Fleet, which includes 842 vehicles and about 470 equipment units operated by the following City user groups:

- Mayor’s Office
- Community Services Department
  - Culture & Recreation Services
  - City Clerk
  - Information Services
- Corporate Services Department
  - City Clerk
  - Information Services
- HECFI
- Library
- Planning & Economic Development Department
  - Building & Licenceing
- Public Works Department
  - Capital Planning & Implementation
  - Energy, Fleet & Facilities
  - Operations & Maintenance
  - Waste Management
  - Water and Wastewater

The other major fleets in Hamilton are managed separately by Fire and Emergency Services (167 vehicles), Police (303 vehicles) and Transit (245 vehicles). These fleets have implemented green technology such as hybrid vehicles and biodiesel and have participated in the creation of this document through the Central Fleet Advisory Committee.

Table 5
Top 10 Fuel User Groups in Hamilton

<table>
<thead>
<tr>
<th>User Group</th>
<th>2008 Fuel Used (litres - excluding natural gas)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transit Division – Public Works</td>
<td>5,906,000</td>
</tr>
<tr>
<td>Roads Section – Public Works</td>
<td>1,999,000</td>
</tr>
<tr>
<td>Waste Management Division – Public Works</td>
<td>588,000</td>
</tr>
<tr>
<td>Hamilton Police Services – supplied through Central Fleet</td>
<td>460,000</td>
</tr>
<tr>
<td>Water and Wastewater Division – Public Works</td>
<td>424,000</td>
</tr>
<tr>
<td>Parks Section – Public Works</td>
<td>396,000</td>
</tr>
<tr>
<td>Emergency Medical Services</td>
<td>330,000</td>
</tr>
<tr>
<td>Hamilton Fire</td>
<td>307,000</td>
</tr>
<tr>
<td>Forestry and Horticulture Section – Public Works</td>
<td>215,000</td>
</tr>
<tr>
<td>Parking &amp; Bylaw Enforcement Operations – Planning &amp; Economic Development</td>
<td>204,000</td>
</tr>
</tbody>
</table>
4. **Strategy**

Reduce petroleum fuel used by City fleet vehicles.

Keep sending the message to other government levels, technology developers, and market and vehicle manufacturers to make more fuel-efficient vehicles, and place firm orders for practical uses of new technology in our fleet.

**Table 6**

*Number of green vehicles added to the Central Fleet 2006-2008, compared to Phase 1 target*

<table>
<thead>
<tr>
<th></th>
<th>Pre- 2006 Total Green Units</th>
<th>2006-2008 Target Additions</th>
<th>2006-2008 Actual Additions</th>
<th>Total Green Vehicles Dec 31/08</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hybrid cars and utility vehicles</td>
<td>14</td>
<td>35</td>
<td>66</td>
<td>80</td>
</tr>
<tr>
<td>Hybrid pickup trucks</td>
<td>1</td>
<td>11</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>Natural gas vans</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Micro cars (Smart)</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Electric utility vehicles (Gator)</td>
<td>5</td>
<td>0</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>“Idle-free” cab heaters</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Auxiliary battery packs</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Regenerative-air PM10 sweepers</td>
<td>4</td>
<td>0</td>
<td>13</td>
<td>17</td>
</tr>
<tr>
<td>Solar-powered arrow boards</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>Total Central Fleet</td>
<td>44</td>
<td>46</td>
<td>105</td>
<td>149</td>
</tr>
<tr>
<td>Police</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire/EMS</td>
<td>7</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transit</td>
<td>15</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Hamilton Fleet</td>
<td>130</td>
<td></td>
<td>174</td>
<td></td>
</tr>
</tbody>
</table>

These vehicles have been added to the Central Fleet. The Transit Division fleet includes 94 natural-gas powered buses and 12 hybrid diesel-electric buses, with 18 more hybrid buses being delivered in 2009, and there are hybrid vehicles in the Police and Emergency Services fleets as well.
5. Tactics

5.1 Green Fleet Expo

In partnership with the City of Toronto, Fleet Services Division and Fleet Challenge Ontario, the City of Hamilton’s Public Works Department hosted Green Fleet Expo (GFX) events in 2006 in Toronto, 2007 in Hamilton and in 2008, again in Toronto. The Green Fleet Expo attracted fleet managers and decision makers from all levels of government to see “green technology” used in both Hamilton and Toronto municipal fleets. The 2008 Green Fleet Expo attracted a delegation from Japan, representing Toyota autoworkers and dealers. GFX-IV is scheduled for May 2009 in Hamilton.

5.2 E3 Fleet Rating System 2006-07

City of Hamilton’s Central Fleet became the first fleet in Canada to be recognized for its progress in reducing fuel consumption and GHG emissions by receiving a performance rating from the E3 Fleet Rating System on May 24, 2007.

This program is offered by the Fraser Basin Council in Vancouver. It was launched in 2006 and by 2008 there were 50 fleets registered in the system.

Fleets are rated on their progress in implementing measures to reduce fuel consumption and greenhouse gases, using a 100-point scale. Hamilton is rated at the Silver level with 67 points. Only one other fleet has surpassed this level as of this date.

The E3 Fleet Review audited our performance in 10 categories:

1. Green Fleet Action Plan
2. Training and Awareness
3. Idling Reduction
4. Vehicle Purchasing
5. Fuel Data Management
6. Operations and Maintenance of Vehicles
7. Trip and Route Planning
8. Utilization Management
9. Fuel Efficiency
10. Greenhouse Gas Reductions

5.3 Fleet Challenge Ontario Project 2007-08

Fleet Challenge Ontario, which is affiliated with the E3 Fleet Rating System, provided an opportunity for Ontario municipal fleets to replicate Hamilton’s successful experience.

The project provided participating municipalities with in-depth municipal fleet reviews, invitations to three workshops on green fleet concepts, a “Best Practices Manual” for implementation and maintenance of a green fleet, and an opportunity to publicly demonstrate a commitment to “being green”. Hamilton was represented at all three workshops and featured in the “Best Practices Manual”.

The project received very strong interest, with 53 municipalities applying for the reviews, of which 12 were selected.
5.4 Electric Vehicle Technology Road Map (evTRM) 2008-2009

In 2008, Central Fleet was invited to join a group developing a plan called the Electric Vehicle Technology Roadmap (evTRM). This group is designing a road map to accelerate the use of electric-powered vehicles in Canada to replace petroleum-fuelled vehicles. The group is headed by Electric Mobility Canada and a team representing Natural Resources Canada and Infrastructure and Transport Canada. Participants represent diverse sectors with an interest in electric vehicles, including the Canadian Space Agency, which is working on the next lunar rover for NASA. Manufacturers including General Motors, Ford, Subaru and Azure Dynamics, battery specialists including Electrovaya, hydro utilities including Hydro-Québec and Manitoba Hydro, non-government organizations and many other user types are all represented. Other municipal fleets involved with this project include the City of Toronto and the Greater Vancouver Regional District.

5.5 Environmental Management System Standard ISO 14001

The Central Fleet Garage became the first business unit in the City of Hamilton to become registered to the ISO 14001:2004 standard for environmental management systems. Registration was achieved in 2007. The major impact on the environment from the Central Garage is discharge of wastewater from washing trucks and buses every day. There is also a very large quantity of fuel held in underground tanks, which requires a high quality monitoring and leak detection system. Other impacts include the generation of waste materials including oil and antifreeze, and solid waste sent to landfill.

5.6 Bulk Fuel Tank Rationalization

Central Fleet maintains 24 fuel sites at various locations across the City. As part of the yards rationalization project in the Public Works Department, the closure of one or more sites may be possible, provided that client divisions are in agreement. This will reduce the City’s exposure to ground contamination from failed storage tanks.

5.7 Greenhouse Gas and Air Contaminants Inventory Study

Central Fleet is participating in a study being done in 2009 by the Air Quality Coordinator in the Planning & Economic Development Department. This study will establish a database of emissions from City operations, including vehicles and buildings, as well as the entire community. With this information, progress in reducing emissions can be reported to stakeholders.

5.8 Clean Air Hamilton

Central Fleet participates regularly in Clean Air Hamilton meetings and has provided a draft of this Phase 2 plan for their comments.

5.9 GreenApple Ranking

The GreenApple Ranking Report has placed Hamilton 8th of 27 Canadian cities in its 2008 SMART Transportation Ranking. The GreenApple Ranking Report recognizes the actions of municipal governments to promote the use of
sustainable urban transportation in their communities. The Green Fleet Implementation Plan and the City’s use of alternative-fuel vehicles were cited as important factors in the Report.

The GreenApple Ranking Report, released by the Appleton Charitable Foundation in conjunction with the Sauder School of Business at the University of British Columbia, assesses transportation policies in Canada’s largest urban areas. The Report ranks municipal policies based on 17 indicators in four policy categories, including air quality, public policy, transport policy and technology adoption.

5.10 FLEETtool.ca 2008-09

City of Hamilton’s Central Fleet participated in a pilot project sponsored by Natural Resources Canada, and delivered by the Clean Air Partnership, a non-profit organization based in Toronto. With the assistance of Bronson Consulting in Ottawa, a comprehensive program to assist fleets in implementing green fleet technology has been developed.

The central feature of the project is an on-line program called FLEETtool.ca. FLEETtool.ca represents the next evolution of the E3 Fleet Rating System and the valuable direction offered through their municipal fleet reviews. Several other fleets are also participating in the pilot project, including Brampton, Ajax, Caledon, Markham and NB Power from New Brunswick. The project was launched May 28, 2008 and concluded January 31, 2009. There are no fees charged to participate in this program.

The following section from pages 15 to 52 is from the FLEETtool.ca catalogue of measures that can be taken to reduce fuel use and greenhouse gas emissions. There has been some editing to put the measures into the context of Hamilton’s Central Fleet. Natural Resources Canada has given their permission to reprint this section.

FLEETtool.ca gives fleet managers the tools and resources they need to measure their fuel consumption and identify opportunities to reduce their fuel consumption, reduce greenhouse gas (GHG) emissions and save money.

With FLEETtool.ca, fleet managers are able to:

- Calculate a fuel consumption baseline
- Build scenarios to reduce fuel consumption
- Develop a fuel consumption action plan
- Measure performance after implementing fleet efficiency actions

There are six categories for fuel reduction identified in FLEETtool.ca for consideration:

1. Aerodynamics
2. Components
3. Driver Behaviour
4. Fleet Management
5. Fuels & Technology
6. Maintenance

Within each of these categories, individual tactics are presented, many with good prospects for success in a municipal fleet. A total of 27 tactics in six groups are reviewed in FLEETtool.ca.

Group 1. Aerodynamics

Objective: Reduce aerodynamic drag to cut fuel consumption.

At highway speeds, over half of a heavy-duty truck’s engine power is used to overcome aerodynamic drag. For long-haul truck operators, changes in the aerodynamic design of tractor units can help improve fuel economy.

Aerodynamic drag on light-duty vehicles can be reduced by selecting a smaller, lower-slung vehicle, removing roof racks when not in use, and operating pickups with the tailgate closed and with a partial cap over the truck bed.

Technologies that improve aerodynamics:

- **Tactic 1. Aerodynamic tractors**
- **Tactic 2. Gap Closing Devices**
- **Tactic 3. Cab roof deflectors**
- **Tactic 4. Trailer side skirts**
- **Tactic 5. Rear boat-tails**
- **Tactic 6. Roof racks**

**City of Hamilton Note:**
As municipal vehicles seldom travel at highway speeds for any significant percentage of total driving, investment in aerodynamic devices does not appear to be warranted.

Group 2. Components

**Tactic 7. Air Conditioners**

The power needed for air conditioning can increase a car’s fuel consumption by as much as 21%.

**How to avoid using the air conditioner**

To avoid using the air conditioner:

- **Keep the vehicle cool** — don’t park in direct sun, and consider tinted windows.
- **Use the vehicle’s venting system** — when getting into a hot car, open the windows and turn the fan to high to blow out the hot air instead of switching on the air conditioning. Fan speed does not have any measurable effect on fuel economy.

When using the air conditioner is necessary:
• **Set the air intake to “recirculated”** — it will use less energy than cooling the hot outside air.

**Air conditioner maintenance**

The refrigerant contained in a vehicle’s sealed air conditioning system causes climate change. If the air conditioner suddenly seems to be less effective, the refrigerant may be leaking. Repairs should be done without delay to avoid increased GHG emissions.

In older cars, the refrigerant used for the air conditioning system, known as R12 was made up of chlorofluorocarbons (CFCs), which have been shown to "eat into" the protective layer of ozone in the earth's upper atmosphere. CFCs have a global warming potential 2,400 times higher than CO2 (expressed as “GWP 2400”).

In response to the ozone threat, the refrigerant industry converted from R12 to a new formulation. All cars built since 1995 have a refrigerant known as HFC-134a (hydrofluorocarbons, also known as R-134a) in their systems and many older cars had their systems converted. The conversion from R12 to R134a (GWP 1300) is an example of how government and industry worked together to find an alternative to a necessary health and comfort part of a vehicle that was found to have an environmental impact.

But while R134a is not an ozone-depleting chemical, it is a greenhouse gas that can increase global climate change. R134a is an improvement over CFCs, and research is continuing to find a replacement for R134a – one that is not a greenhouse gas. There are several new refrigerants (GWP < 50) being tested to determine their safety and viability, but every indication is that new refrigerants will be commercially operational and available by the time Europe’s ban on R134 takes effect at the end of 2011. The new gases are important not just because they will have an extremely low GWP, but also because, unlike flammables and CO2 refrigerants, these new refrigerants can be safely used in current A/C systems with very little mechanical modification and little need for expensive changes in aftermarket service procedures.

**Effect of air conditioning on fuel economy**

Air conditioning draws power directly from the engine. It also decreases fuel efficiency by adding extra weight to the vehicle. Other variables influence how air conditioning affects fuel efficiency:

- **Engine size** — a powerful V-8 engine can better handle the extra power draw than smaller engines can. For economy cars or gas-electric hybrids, air conditioning has a proportionally much larger effect than for full-size sedans or light trucks.

- **Climate** — A/C power consumption varies strongly with ambient air temperature and humidity, and depending on whether air is recirculated or not. In very hot, humid weather, the air conditioner works harder than at more moderate temperatures, particularly if the already-cooled air inside the vehicle is not being recirculated back through the unit.
• **Driving speed** — Air conditioning draws more power and thus consumes more fuel at higher speeds — from an average of 2 horsepower (Hp) at idle, up to 6 Hp to 9 Hp when driving.

**A/C on versus windows down**

Air conditioning has a bigger drain on fuel economy than having the windows down, in both wind tunnel and on-track testing of SUVs and full-size sedans at both city and highway speeds.

<table>
<thead>
<tr>
<th>City of Hamilton Note: Air Conditioner Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air conditioning is common in Central Fleet vehicles, and driver training to improve fuel economy refers to the impact of using the air conditioning system. Most Central Fleet technicians have “ozone-depletion licences”, which is a legal requirement in order to work on vehicle air conditioners.</td>
</tr>
</tbody>
</table>

**Tactic 8. Auxiliary Power Units**

Auxiliary power units cut fuel use by more than 80% compared to idling and save wear and tear on the engine.

- An average transport truck idles for up to 2,400 hours per year.
- Heating the cab or sleeper compartment of a heavy-duty vehicle by idling is very inefficient. It wastes over 85% of the energy in the diesel fuel.
- Cooling the cab with air conditioning wastes 94% 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. APUs are battery or diesel powered, or a combination of both. There are two types of APUs: direct-fired heaters and true APUs.

**Direct-fired heaters**

Direct-fired heaters are usually engineered only to heat the cab, although one type also provides cooling. The following table describes the three types of direct-fired heaters:
Table 7

Types of direct-fired heaters

<table>
<thead>
<tr>
<th>Type</th>
<th>Powered solely from the vehicle’s battery</th>
<th>Powered by both battery and diesel fuel</th>
<th>Relies on a battery pack to run both a heater and an air conditioner</th>
</tr>
</thead>
</table>
| Operation                         | • Circulates the heated coolant from the engine to the heater coils, which can keep the cab warm for up to 4.5 hours.  
• Includes a temperature sensor and a voltage sensor.  
• Burns no fuel, and draws less than an amp from the battery. | • Typically operates for about 20 hours on less than four litres of fuel.  
• Includes automatic temperature controls, and is completely separate from the vehicle’s heating system. | • Runs for 10 hours, and requires four to six hours for a full recharge. |
| Weight                            | About 1.3 kilograms                       |                                         | Over 91 kilograms                                                   |
| Cost                              | Under $600                               | About $1,600                             | About $4,000                                                      |

**Auxiliary power units**

True APUs have a separate engine. They are engineered to provide not only heat, but also air conditioning and power to the cab.

Operation — An internal combustion engine (generator), a compressor and an alternator, and are generally diesel powered.

Cost — From $7,000 to $9,250.

Fuel consumption — Consume anywhere from 0.38 to 1.14 litres of fuel per hour, which represents a savings of 63% to 88% over the three litres per hour typical of idling fuel consumption.

**City of Hamilton Note: Auxiliary Batteries**

Hamilton’s Central Fleet has added auxiliary batteries to six vehicles used by the Surveys section in the Public Works Department, so that the crews can use the vehicle’s safety/traffic direction lighting without leaving the engine running. Fuel statistics are shown in Table 8.
Table 8

*Fuel reduction due to auxiliary batteries*

<table>
<thead>
<tr>
<th>Vehicle number</th>
<th>Fuel use before (L/100 km)</th>
<th>Fuel use after (L/100 km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>290601</td>
<td>29.2</td>
<td>28.6</td>
</tr>
<tr>
<td>290602</td>
<td>25.4</td>
<td>26.0</td>
</tr>
<tr>
<td>290603</td>
<td>29.4</td>
<td>26.1</td>
</tr>
<tr>
<td>290701</td>
<td>26.4</td>
<td>27.3</td>
</tr>
<tr>
<td>290702</td>
<td>27.2</td>
<td>23.6</td>
</tr>
<tr>
<td>290703</td>
<td>35.3</td>
<td>31.0</td>
</tr>
<tr>
<td>Average</td>
<td>28.8</td>
<td>27.1</td>
</tr>
</tbody>
</table>

**Tactic 9. Block Heaters**

Plugging in a vehicle for two hours before starting it can reduce fuel use and emissions by up to 10%.

A block heater is an electric heater that heats the engine of a vehicle to ease starting in cold weather. It is connected to normal AC power before driving, via regular power plugs that are fed through the vehicle’s grille. This allows easier starting in cold temperatures, by keeping the engine coolant warm.

- **Optimum plug-in time** — an automatic timer can switch on the block heater two hours before the vehicle usually starts its duty cycle. This reduces electricity consumption.

- **Criteria air contaminants (CAC) emissions reductions** — Using block heaters reduces CAC emissions, specifically carbon monoxide (CO), since CO emissions are elevated at cold ambient temperatures and are therefore of primary concern during the winter.

**City of Hamilton Note:** Hamilton’s waste collection fleet of about 38 trucks is parked outside and the block heaters are plugged in overnight during cold weather months. A larger number of fleet vehicles are parked inside and block heaters are not needed. Central Fleet and the Office of Energy Initiatives are investigating the use of timers to reduce electricity consumption. Turning block heaters on two hours before driving is just as effective as leaving them on all night.

**Tactic 10. On-Board Computers**

Using on-board computers and driver training programs improves fuel efficiency. Various studies have demonstrated the value of on-board computers when used in conjunction with driver training programs:

- A 2003 Belgian study found that six months after receiving driver training, drivers with on-board computers used 4% less fuel than those without.

- A 2004 French study for Renault found that after receiving driver training, drivers of heavy trucks tended to revert to ingrained driving habits over
time. However, with a well-designed assistance system, a 4% to 10% margin in reduced fuel costs was observed within a fleet of trucks.

On-board computers encourage good driving practices by providing helpful data and by monitoring driving. They are usually used in conjunction with driver training programs.

- **Data** — Drivers can access the data collected and stored in the on-board computer via the vehicle display unit (vdu), a touch-screen mounted on the dashboard. Standard features include the recording of trip data, such as distance, time, vehicle speed and engine speed. Previous trips are stored in the memory for up to a month, so the information can be downloaded for analysis by fleet managers.

- **Warning** — a buzzer notifies the driver in case of a driver violation such as speeding, over-revving, harsh braking, hard acceleration or excessive idling. This warning is recorded in the trip memory.

**City of Hamilton Note:** Hamilton has not used this technology widely, although some of our hybrid vehicles display fuel consumption on a dashboard monitor or on the instrument panel. The City of Vancouver has examined the use of “Eco-meters” in their fleet. There are nearly 20 different types available, ranging in price from $160 to around $500 each. The Vancouver study concluded that drivers who paid attention to the information were able to reduce fuel use between 10% and 30%.

**Tactic 11. Roof Racks**

Reducing aerodynamic drag cuts fuel consumption for light-duty vehicles. At highway speeds, about 50% of a light-duty vehicle’s engine power is used to overcome aerodynamic drag. One effective and inexpensive way to reduce aerodynamic drag is to remove roof racks when they are not required.

**City of Hamilton note:** A few vans in Hamilton’s fleet have permanent ladder racks, and a number of pickup trucks in Public Works have folding traffic direction lighting mounted over the roofline.

**Tactic 12. Tires**

Choosing the right tires reduces fuel consumption and costs, and GHG emissions.

Tread design, material composition and the cross-sectional geometry of a tire can create significant differences in the rolling resistance and therefore in the fuel economy associated with different tires.

For large trucks this means:

- Using more efficient tread types can improve fuel economy by 2% to 14%.
- Switching to wide-base tires can improve fuel economy by 2% to 7%.

**Rolling resistance**
The National Research Council estimates that 80% of the fuel energy that goes into cars and trucks is used to overcome frictional, thermal and other losses. Tires contribute to energy loss through rolling resistance.

**What is rolling resistance?** Rolling resistance is resistance to the motion of the vehicle that is caused by the tire and its interactions with the road, the air and the tire rim.

**When does it occur?** Most rolling resistance occurs when the tire compresses and then rebounds to its original shape as it rolls. The energy that goes into the compression is used to return the tire to the original shape and is lost as heat. Aerodynamic losses as the tread pattern moves through the air and frictional losses (tire/road and tire/rim) are smaller contributors to rolling resistance.

**What percentage of energy is lost?** The amount of energy used to overcome rolling resistance in large trucks is estimated at 12% of all losses; only engine and aerodynamic losses are larger. Therefore, proper tire selection is important for improving fuel economy.

**What can be done?** Operational requirements generally dictate the types of tires used by heavy-duty trucks. Safety and tire replacement costs are two factors that must be weighed against fuel efficiency. However, operators do have a certain amount of choice in tires, and choices made about tire design, tire size, tread depth and tread configuration can influence overall fuel efficiency.

**Tread type**

Tread design and depth contribute to reduced rolling resistance by reducing empty space on the surface of the tire, something that mechanically reduces flex and deformation.

**Tread depth** — generally, the shallower the tread depth, the better the fuel economy. But reduced tread depth will lead to reduced tire life.

**Tread design** — using tires with a ribbed, rather than lugged, tread also results in better fuel economy. But such design can lead to reduced traction on wet or loose surfaces.

Changing to a more efficient tread type can improve fuel economy by 2% to 14%, depending on the type of original and replacement tires. However, to maintain handling and control, be careful to make sure the selected tire is appropriate for the vehicle and its operating conditions.

**Wide-base tires**

Wide-base, or single-wide, tires are specifically designed to reduce rolling resistance in situations where dual-wheel assemblies would normally be used. As the name implies, they have a wide base area to make contact with the road, but there is only one tire in each assembly, as can be seen in the figure below.

Switching to wide-base tires can improve fuel economy by 2% to 7%.

- **Reduced rolling resistance** — the rolling resistance of wide-base tires is reduced because there are only two sidewalls (instead of four on a dual-tire assembly). This reduces the overall amount of
material that is subject to flex and deformation, and therefore to energy loss. The overall effect can be to reduce rolling resistance by as much as 30%.

- **Additional benefits** — Wide-base wheels are lighter, providing an opportunity to increase payload or to bank some additional fuel savings. Also, the design of wide-base tires means that their centerline is typically further from the centerline of the truck, lowering the centre of gravity and improving lateral stability.

- **Additional cost** — Wide base tires need special wheel rims that cost about $3,000 per truck.

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**City of Hamilton Note: Tire Selection**

Central Fleet will be investigating the use of alternative tread designs and wide base tires during Phase 2 of the Green Fleet Implementation Plan. Tires have a larger impact on long-haul highway transport trucks than in City operations, so changing tire specifications may not have a payback to the City.

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**Group 3. Driver Behaviour**

Individual driver behaviour can dramatically affect fuel consumption.

**Tactic 13. Aggressive Driving**

Driving aggressively can increase fuel consumption by up to 33%. Studies have shown that driving aggressively will not reduce travel time, but will increase fuel consumption and chances of being involved in an accident. Aggressive driving is defined as speeding, rapid acceleration and frequent braking. For more information related to the effects of speeding on fuel efficiency, see the Speed section.

**Rapid accelerations and frequent braking result in increased fuel consumption**

- **Accelerating** — during acceleration, the fuel/air ratio is significantly higher than at cruise, so fuel consumption is significantly increased.

- **Frequent braking** — with frequent braking, energy generated by acceleration is often lost. Momentum is also lost, and studies have shown that up to six times more gas is required to move a car from a complete stop than if the car has a momentum of even a few kilometers per hour.

**Fuel-efficient driving styles**

Driving styles that are more fuel-efficient than aggressive driving include:

- **Defensive driving** — this method is based on anticipating traffic situations in order to avoid sudden and unnecessary braking or quick lane changes.

- **Egg style** — this method focuses on slow acceleration (as though there is an egg under the gas pedal that the driver must not break).
• **Ecodriving** — this method combines elements of defensive driving and egg-style driving, advising gentle acceleration, smooth driving (avoiding braking, conserving momentum) but combining this with optimum engine operation techniques. See the Driver Training section for more information.

Other ways to reduce aggressive driving include using On-Board Computers and Cruise Control.

**City of Hamilton Note: Denver’s “Driving Change” Program**

The City and County of Denver implemented a program inviting drivers of municipal and privately owned vehicles to measure and report on driving behaviours that waste fuel and increase GHG emissions. Monitoring devices transmit instances of speeding, idling, fast starts and hard braking, and calculate the increase in GHG emissions for review on-line by drivers. The program is funded by a partnership including the City of Denver and several private firms.

This initiative will be presented to Clean Air Hamilton and Fleet Challenge Ontario to assess the interest of duplicating the program in Hamilton.

**Tactic 14. Cruise Control**

Cruise control can reduce fuel consumption by about 5% to 7%, by maintaining a constant vehicle speed.

Cruise control can help drivers to reduce their speed variability, as well as their overall speed, but it is generally not recommended for use on city streets or on hilly terrain.

**City of Hamilton Note:** Only a few of Hamilton’s light-duty vehicles are equipped with cruise control. The majority of vehicles do not have it and it is not available on many types of vehicles used by the City.

**Tactic 15. Idling, Light-Duty Vehicles**

Idling has been found to make up about 25% of total operating time for light-duty vehicles. If every driver in Canada reduced idling by five minutes for just one day, it would save over 2 million litres of fuel (based on 1.45 L of fuel consumed per hour of idling, and 18,182,683 light-duty vehicles on the road). While this is only 2% of fuel used by light-duty vehicles in this country, it is a sizeable amount.

**Idling to warm-up a vehicle**

Remote starts result in unnecessary idling and wasted fuel. In the winter, vehicles should only be idled long enough to ensure the windows are clear before setting off. In the summer, no warm-up idling is necessary.

A vehicle should be warmed up by idling only to defog and defrost the windows. No vehicle should be operated with frosted windows. The idling time required to achieve this will vary by vehicle, and also with temperature and weather conditions. The following two situations do not warrant idling to warm up a vehicle:
• **To warm the interior of the vehicle** — the interior of the vehicle will warm up more quickly if the vehicle is driven rather than idled.

• **To warm up the engine** — It is becoming increasingly accepted that it is poor practice to idle a vehicle to warm up the engine, since driving a vehicle reduces the warm-up time by half. Idling is therefore not an effective way to warm up a vehicle, even in cold weather. The best way to warm a vehicle is to drive it, at least from a fuel consumption standpoint.

An alternative to idling to warm up a vehicle is to install a **block heater**.

**Idling versus restarting a vehicle**

Switch your vehicle off if you are stopping for more than 10 seconds in either warm or cold weather.

• **In warm weather**, idling will consume more fuel than shutting off a vehicle, for virtually all time intervals. The longer the engine idles, the more fuel gets wasted. Restarting does not produce any more criteria air contaminant (CAC) emissions than idling. From a fuel consumption and emissions standpoint, idling for any period of time cannot be justified.

• **In cold weather**, the engine cools much more quickly, and restarting requires more fuel. But idling for 10 seconds still consumes more fuel than restarting. In terms of emissions, CO emissions are higher when you drive with a cold engine. The catalytic converter will stay warm enough that the emissions control system will still be efficient.

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**City of Hamilton Note: Fleet Challenge Ontario Police & EMS Vehicle Idling Reduction Demonstration Project (PEMS).**

In 2008, Central Fleet management was invited by Fleet Challenge Ontario to work on a project funded by the Ontario Ministry of Finance to implement the Province’s “Going Green” initiative. Hamilton Emergency Services and Hamilton Police Services are both volunteering to have vehicles equipped with technology that will measure and reduce idling. The primary goals are to reduce fuel costs and harmful emissions from engine idling.

**Tactic 16. Idling, Heavy-Duty Vehicles**

Idling for more than five minutes wastes fuel and produces unnecessary harmful emissions.

• **Average daily fuel consumption due to idling** — various studies show the average fuel consumption rate due to idling is about three litres per hour. If an average long-haul truck idles all night long (assume eight hours), it wastes 24 litres of fuel due to idling per day. This is the same amount of fuel estimated to be wasted per year for the average light-duty vehicle.

• **Average yearly fuel consumption due to idling** — total idling per year has been estimated at 1,830 hours to 2,400 hours per year for the average long-haul truck. That is equivalent to 50,000 litres of wasted diesel fuel per year for every truck on the road.
• **Emissions of CACs and GHGs from heavy truck idling** — while idling, a typical heavy truck emits 2.59 grams per hour of PM10, 144 g/h of NOx, and 8224 grams per hour CO2. Over an average stop of eight hours, this amounts to over 20 grams of PM10, 1,150 grams of NOx and 705,500 grams of unjustifiable CO2 emissions.

• **Vehicle component wear considerations** — The American Trucking Association estimates that excessive idling increases yearly maintenance costs by up to $2,000 per vehicle.

**Reduce idling costs**

Idling profiles vary considerably depending on the type of truck and operation, the habits of individual drivers, and the season.

- **Heavy trucks need no more than five minutes of idling to warm up or cool down the engine.** Most new diesel engines will stay warm for several hours after they have been running, retaining more than enough heat to keep the engine warm and avoid starting difficulties. Similarly, diesel fuel will no longer “gel” in cold weather when an engine is turned off, because Hamilton uses winter blends that better withstand colder temperatures.

- **Block heaters** can be used to minimize idling time during warm-up, especially in cold weather.

**Vehicle component wear considerations**

Frequent restarts are not an issue for heavy-duty vehicles, as idling tends to occur in very long increments, rather than in shorter spurts. The main consideration for heavy-duty vehicles is potential deterioration due to excessive idling.

- The **US EPA** states that too much idling will require increased oil changes and lead to wear and tear on engine components. Increased maintenance costs to truck owners are estimated at $1.13 per day.

- The **American Trucking Association** presents a bleaker picture. It claims that excessive idling increases yearly maintenance costs by up to $2,000.

**City of Hamilton Note: Acquiring Heavy-Duty Hybrid Vehicles**

Waste collection trucks and forestry aerial trucks are the two categories of City vehicles that consume the most fuel, measured on the basis of litres per 100 kilometers traveled. Waste collection trucks use 100 litres/100 kilometers due to their size, weight, and the fact that they stop and start about 1,500 times per day. Forestry aerial trucks run their engines for long periods of time while stopped at a job site in order to operate the hydraulic aerial boom to reach tree tops and branches, and typically use 85 litres/100 kilometers.

Council approved report PW08106 that will allow the Waste Management Division to acquire three hybrid hydraulic launch-assisted hybrid trucks for the multi-residential Green Cart program. These are not similar to hybrids now in our
Eaton Corporation’s Roadranger hybrid system uses a hydraulic system to accelerate and brake the truck, reducing engine speeds and brake system wear. Pricing is not known as of this time and so a firm commitment has not been possible.

Eaton also builds a diesel-electric hybrid system designed for aerial trucks. First launched in 2005, it will be considered for the next Forestry replacement, due in 2010. There are no other replacements planned before 2012.

**Tactic 17. Speed**

Increasing speed from 100 km/h to 120 km/h can increase fuel consumption by 20%.

- For most vehicles, the most economical speed is 80 km/h to 90 km/h on the highway. At higher speeds, fuel consumption increases. Fuel loss is about 1% for each kilometer-per-hour increase in speed.
- Reducing highway speed from 120 km/h to 100 km/h saves $10 on a $50 fill-up at the pumps.
- In urban areas, drivers can increase their fuel efficiency by reducing their speed to 50 km/h.

Possible solutions include the use of on-board computer displays and cruise control as well as driver training.

**Fuel efficiency and speed**

Every vehicle requires a fixed amount of fuel to keep the cylinders moving and the various fans, pumps and generators running. Above and beyond this, however, it also requires fuel to propel the vehicle. The power required by the engine increases exponentially with the vehicle’s speed.

- **When the vehicle is stationary**, the power is also zero. But the vehicle continues to use fuel to keep the components operating. Therefore vehicles have the worst fuel economy at 0 km/h; they use gasoline without logging any kilometers.
- **As the speed increases from 0 km/h**, fuel efficiency increases very quickly, because in terms of fuel used per kilometer, the faster the vehicle goes, the better use it makes of the fixed amount of fuel required to keep the components operating.
- **Eventually the fuel efficiency curve begins to level out**. At higher speeds, even small increases in velocity require increasingly more power, and thus fuel. At even higher speeds, the power required surpasses the engine efficiency improvements, and the fuel efficiency starts dropping.

**City of Hamilton Note: Speed Limiters**

Speed limiters are a legal requirement in Ontario for heavy trucks. The Central Fleet has 248 vehicles in this category. The engine control module is being reset in each truck to limit the maximum speed to 105 km/h to comply with the regulation.
Tactic 18 Winter Driving

Winter driving consumes more fuel, and in turn creates more emissions from vehicles.

[Hamilton winters are variably mild or cold and occasionally roads are covered with snow or ice.] This presents challenges not only to safe driving, but also to fuel-efficient driving. In cold temperatures, certain aspects of a vehicle’s technical operation become more difficult: tires routinely lose pressure when the temperature drops, poor road conditions demand more traction than is available using regular tires, oils and lubricants become thicker and less effective, and windows frost up, fog up or are covered in ice and snow. Possible solutions to help drivers stay safe and drive fuel efficiently all winter long include:

- **Use block heaters** — plugging in a vehicle for two hours before operating start can reduce fuel use and emissions by up to 10%. It will also reduce engine wear. See the block heaters section.
- **Reduce idling** — idle only long enough to make sure the windows are clear before setting off. In the summer, no warm-up idling is necessary.
- **Drive smoothly and obey the speed limit** — Jackrabbit starts and frequent braking will drive up fuel consumption and emissions even more in the winter. See the aggressive driving and speed sections.
- **Check tire pressure regularly** — Tire pressure can drop when the temperature goes down, which in turn affects fuel economy. Tire pressure should be checked regularly during the winter, particularly after a sharp drop in temperature. See the sections on tire maintenance for heavy and light-duty vehicles.

City of Hamilton Note: Hamilton has installed new tire-filling stations in the Central Garage, next to the windshield washer fluid dispensers.

Snow tires

Snow tires are designed with deeper treads to increase traction on wet or loose surfaces. Tread design, specifically tread depth, influences both the rolling resistance and the weight of the tire.

- **Rolling resistance** — the increased tread depth of winter snow tires increases the empty space on the surface of the tire, something that mechanically reduces its ability to flex. See the Tires section.
- **Weight of the tire** — deeper tread depth also implies more material in the tire, adding a weight penalty that will further decrease fuel economy.

City of Hamilton Note: Snow tires are not recommended for City of Hamilton vehicles, due to the increased fuel consumption and higher wear. Most Central Fleet vehicles have truck tires that provide sufficient traction. It should be noted that snow tires do not stop a vehicle as fast as all season tires on dry pavement.
A survey of other Canadian municipalities in 2009 found that Hamilton’s practice is consistently used in most cities.

**Group 4. Fleet Management**

Fleet management is a general term for a broad range of initiatives supported and led by management to make a vehicle fleet more effective and efficient.

**Tactic 19 Driver Training**

Driver training can reduce fuel consumption by 5% to 10% or more, and will cut down on accidents.

- Several driver training programs help increase fuel efficiency, by teaching driving styles such as **defensive driving**, **egg-style driving** and **ecodriving**.

- **On-board computers** reinforce driver training by providing drivers with immediate and continuous feedback on fuel savings.

**Defensive driving** is based on anticipating traffic situations to avoid sudden and unnecessary braking or quick lane changes. Defensive driving is the usual method used in programs that focus on safety and accident reduction. But it has the added benefit of reducing fuel consumption, because it reduces all three components of aggressive driving: high speed, hard acceleration and frequent braking.

**Egg-style** driving focuses on slow acceleration (as though there is an egg under the gas pedal that the driver must be careful not to break).

**Ecodriving combines** elements of defensive driving and egg-style driving, advising gentle acceleration and smooth driving (avoiding braking, conserving momentum).

The fundamentals:

- Avoid unnecessary braking: look ahead and anticipate traffic flow and red lights.

- Decelerate smoothly by releasing the accelerator in time, leaving the car in gear. In this case, modern engines do not use any fuel.

Drivers of automatic transmission vehicles can apply these principles by accelerating gently and driving smoothly.

- **On-board computers** — Ecodriving is more likely to be combined with the use of in-car devices to monitor and report on fuel consumption, which has been shown to significantly increase post-training fuel economy gains. See the section On Board Computers.

- **Benefits of ecodriving** include reduced air pollution, reduced noise pollution, reduced fuel and vehicle maintenance costs, reduced incidence of traffic accidents and, of course, reduced fuel consumption.

**City of Hamilton note: Driver Training**
Central Fleet’s Driver Training service is focused on safety and adherence to regulations for commercial vehicles, which apply to our larger trucks. In 2008 new training was introduced, using the “Fleet Smart” resources from Natural Resources Canada which includes fuel conservation measures.

**Tactic 20 Purchasing Decisions**

A sound purchasing decision is one of the best ways to reduce the impact of on-road transportation on fuel consumption and the environment, particularly for light-duty fleets.

When purchasing light-duty vehicles, fleet managers should:

- **Consider buying a highly fuel-efficient vehicle** — The Fuel Consumption Guide from Natural Resources Canada offers more on buying a new fuel-efficient car or truck.

- **Consider the following fuel-efficient decisions:**
  - Choose front-wheel drive over rear- or all-wheel drive.
  - Consider a smaller engine — fewer cylinders mean less fuel.
  - Choose a continuously variable transmission (CVT) or manual transmission over an automatic.
  - Look for variable valve timing.
  - Consider a hybrid or diesel vehicle.

When purchasing heavy-duty vehicles, fleet managers should:

- **Accurately determine the appropriate vehicle specification required** — this is covered in Natural Resources Canada’s SmartDriver training course. Hamilton’s Central Fleet uses this material for driver education.

- **Consider aerodynamics** — not considered applicable in Hamilton’s operations.

- **Consider freight logistics** — done in consultation with vehicle users.

- **Consider tire selection** — done during the specification writing process.

**Diesel engines**

Diesel engines are about 40–50% more efficient than gasoline engines because diesel has a higher energy content, or heating value, than gasoline. Diesel engines also have the added benefit of being able to operate on biodiesel. They are more expensive than gasoline engines.

**City of Hamilton Note: Minicars**

The Central Fleet purchased a 2006 Smart ForTwo two-seat car for use as a pool vehicle. This vehicle is 96 inches (2.4m) long or half the length of a conventional passenger car. It has a 3-cylinder diesel engine and uses about 4.5 litres of...
The current model Smart ForTwo has a 1.0 litre gasoline engine, is 106 inches (2.5m) long and 61 inches wide. As this car requires premium-grade gas and this is not something the City is able to handle at its bulk fuel storage facilities, there are no plans to add more Smart cars to the Central Fleet. Hamilton Police Services have one Smart car in their pool fleet.

Several minicars are available in Japan. The maximum size in this category is any car with specifications not exceeding a 660 cc engine, 133 inches (3.3m) long and 58 inches wide. Current models include Daihatsu Tanto, Honda Fit, Mitsubishi i, Suzuki Wagon R, Toyota IQ. Mitsubishi is working on an electric version of the “i” mincar, called “i MiEV”.

Th!nk Global of Norway had plans to begin selling its small electric City car in the US in 2009, starting with a demonstration fleet of 50 vehicles aimed at utility companies. Car is 123 inches (3.0m) long and has a range of 175 km. Th!nk halted the plan in January 2009.

**Tactic 21 Transportation Demand Management**

Reducing total kilometers traveled cuts annual fuel consumption, fuel costs and GHG emissions.

Transportation demand management (TDM) helps reduce travel by using strategies that:

- Maximize the use of existing transportation resources
- Employ innovative measures to reduce demand for transportation where practical and appropriate

The ultimate objective of transportation demand management is an overall rationalization or reduction in the demand for transportation resources and therefore a reduction in total kilometers traveled by vehicles. Successful strategies include:

- Trip planning
- Ridesharing
- Discouraging personal (or taxable) use of fleet vehicles
- Eliminating vehicle use

**Trip planning**

Effective trip planning can lead to more efficient use of private vehicles, resulting in reduced fuel consumption and operating expenses. It can also result in less overall time spent traveling. Trip planning includes:

- **Avoiding congested roadways** — Making a trip outside peak travel times, traveling on roads with fewer intersections and crosswalks, and checking traffic reports.
• **Planning an optimal route** — Finding a route that will permit consistent, steady driving with few impediments to slow and then accelerate vehicle speed. A route that allows consistent, steady driving should be balanced with a direct route between destinations, and backtracking should be avoided.

• **Combining short trips into longer ones with multiple stops** — when possible, a number of short trips should be combined into a longer trip with multiple stops, as the vehicle stays warm and operates in a more efficient manner. The engine, engine lubricants and catalytic converter will be warmer when restarting after making stops than they would be if the engine were cold-started over several hours or a number of days. The overall effect of combining the trips will be to limit fuel consumption and emissions.

**Ridesharing**

Ridesharing refers to carpooling and vanpooling. Many light-duty vehicles can comfortably carry three or more passengers. Taking advantage of this capacity by carpooling or vanpooling reduces the overall number of vehicles traveling the same route, and thus results in reduced fuel consumption, lower emissions and less cost.

Rideshare participants may also take advantage of the high occupancy vehicle lanes that are becoming more prevalent in Canada’s large cities. Using these lanes can reduce commuting time and the level of stress associated with driving in congested areas.

Ridesharing can take a number of forms:

• **A designated driver carpool** generally has one driver who provides the vehicle. Passengers pay a fee that is based on expenses such as fuel, maintenance and parking.

• **An alternating carpool** is one in which drivers take turns driving their vehicle on a daily, weekly or monthly basis. Costs are incurred only when an individual is required to drive; passengers ride for free.

• **An employer carpool** uses an employer-provided vehicle so employees can commute to and from work. Employees who use the carpool pay a fee to offset additional fuel, maintenance and insurance costs. This system can have benefits for employers and employees. Employees don’t have to incur expenses for owning a vehicle. Employers can reduce their employee parking and benefit from positive publicity about an environmentally friendly service.

• **Fleet carpool and vanpool programs** are usually organized on a regional basis in large cities. The programs provide groups of commuters with vehicles to travel to and from work or school. Fares are generally used to cover the operating costs of the vehicle and are often based on a per kilometer amount. Drivers are usually volunteers from the group.
Reducing personal use of fleet vehicles

Policies that reduce personal (and therefore taxable) use of fleet vehicles can influence driver behaviour and ultimately encourage reductions in overall demand for transportation resources and in total kilometers accumulated.

Eliminating vehicle use

Eliminating the use of motorized vehicles as much as possible has obvious benefits for reducing fuel consumption and emissions. Additional benefits include less wear and tear on vehicles and no need to find and pay for parking, which can be scarce in urban areas.

- Walking or riding a bike is a good choice for short local trips.
- Public transit should be considered for longer trips, particularly when commuting.

City of Hamilton Note: Car sharing

Car sharing is a model of car rental where people rent cars for short periods of time, often by the hour. Employers can use car sharing programs to provide flexible mobility options for employees on work-related trips and encourage them to take transit or walk to work. Instead of owning one or more vehicles, a household or business accesses a fleet of shared-use autos on an as-needed basis. Individuals gain access to vehicles by joining an organization that maintains a fleet of cars and light trucks in a network of locations. The organization renting the cars may be a commercial business or the users may be organized as a democratically-controlled public agency, cooperative, or ad hoc grouping.

- U.S and Canadian data reveal that each carsharing vehicle removes between 6 to 23 cars from the roads.
- An average reduction of 44% in Vehicle Kilometres Travelled (VKT) per carsharing user across North American.
- In Europe, carsharing is estimated to reduce the average user’s carbon dioxide emissions by 40 to 50%.
- Reducing vehicle ownership and VKT lower greenhouse gas (GHG) emissions, as trips are shifted to transit, biking, and walking.

Fleet partnerships arrangements in car shares for employee usage can partially or fully replace fleet vehicles resulting in cost savings from maintenance requirements, fuel usage, insurance and associated staff costs (i.e. employee mileage claims).

Group 5. Fuels and Vehicle Technology

The choice of fuels and vehicle technology affects fuel consumption and emissions.

Tactic 22 Alternative Fuels

Using alternative fuels can help reduce GHG emissions.
Alternative fuels are made from non-petroleum resources. Viable alternative fuels for vehicles include biodiesel, ethanol, propane and natural gas.

Three additional alternative fuels are not included in this section:

- **Hydrogen fuel cells** are an emerging technology that will become increasingly important. Most automobile manufacturers are now working on promising prototypes for hydrogen fuel cell vehicles, but they are not yet commercially available.

- **Hybrid electric vehicles** are explored in further detail in the hybrid light-duty vehicles and hybrid heavy-duty vehicles sections.

- **Battery electric vehicles** are not addressed in FLEETtool.ca but will be addressed by the City of Hamilton in this section.

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**City of Hamilton Note: Fuel Cell Cars**

Honda FCX Clarity is a four-door sedan now being delivered in California only, limited to about 200 units over the next three years. All customers are limited to those living within easy reach of Honda’s three hydrogen fuel stations in California.

Ford has had a fleet of 30 Ford Focus fuel-cell vehicles in a test since 2005.

Hydrogen is sold by the kilogram for between $5 and $10 per gallon of gasoline equivalent, and the car gets the equivalent of 68 miles per gallon (3.5L/100 km.).

**Hydrogen’s Upside**

Engine exhaust contains only water vapour.

**Hydrogen’s Downside**

It is so light that it has to be compressed or chilled to -253C for storage.

One litre of gasoline (C₆H₁₈) contains 2,900 times more energy than one litre of H₂.

Compression absorbs 10% of the energy stored. This energy is lost when the gas expands. (Automotive News 07/07/2008)

Besides reducing pollutants and GHG emissions, alternative fuels can be domestically produced and come from renewable resources.

- The effect of different types of fuel on fuel economy is related to the energy content, or heating value, of the fuel. Although alternative fuels have many excellent environmental qualities, their fuel economy is generally not as good as conventional fuels, since they have lower energy content.

**Biodiesel**

Biodiesel is made from grain and vegetable oils, waste cooking oil, or waste animal fats. It can be used in its pure form (B100) or blended with petroleum diesel in any concentration. Common blends in use are 5% biodiesel (B5) and 20% biodiesel (B20), and other blends include B2 and B50.
City of Hamilton Note: The City of Hamilton has been using B5 from soybeans at the Central Garage fuel site since 2007. The site dispenses biodiesel from April to September each year in accordance with contracts in place for the supply of conventional diesel. These contracts will be renewed in 2009 and may be amended to include the Transit fleet and to use B5 year-round. The Alberta Renewable Diesel Demonstration reported in 2008 that biodiesel performed successfully in temperatures as low as -44°C.

All diesel vehicles can use blended biodiesel, though manufacturer recommendations differ.

- **Societal and economic benefits** — Biodiesel is produced from local, non-petroleum renewable resources — either agricultural products or agro-industry residues such as slaughterhouse waste, recycled cooking oil, non-food-grade virgin oil or agricultural surplus.

- **Environmental benefits** — Biodiesel is non-toxic and biodegradable, and it produces less air pollutants than petroleum-based diesel. Over its life cycle, pure biodiesel produces 64% to 92% less greenhouse gas emissions than petroleum diesel, depending on what oil or fat is used to make it. B20 produces 12% to 18% less emissions, and B2 produces 1% to 2% less emissions. However, nitrogen oxide (NOx) emissions may be increased.

- **Safety** — Biodiesel is safer to handle than petroleum diesel, since it is considerably less flammable.

- **Vehicle performance** — Biodiesel-powered engines have been shown to deliver similar torque and horsepower as diesel-powered engines. High concentrations of biodiesel can have problems with gelling in cold weather. Solutions to cold weather problems are the same as those for petroleum diesel. They include using fuel additives and engine block or fuel-filter heaters and storing vehicles near or in a building.

- **Vehicle and fuel availability** — Biodiesel can be used in most diesel engines, especially newer ones. However, biodiesel is not yet commercially available in Canada except for a handful of retail sites in Ontario and British Columbia.

- **Cost** — Biodiesel prices vary but currently tend to be slightly higher than those for petroleum diesel.

- **Fuel economy** — Biodiesel has slightly more energy per litre than No. 1 petroleum diesel and slightly less energy than No. 2 petroleum diesel. Compared with No. 2 diesel, B100 has a 10% lower fuel economy, and B20 has a 2% lower fuel economy.

**Ethanol**

Ethanol is a liquid alcohol distilled from agricultural crops, usually corn or wheat. Ethanol is blended with gasoline to produce a fuel that is friendlier to the
environment than gasoline. All post-1980 gasoline vehicles can use E10, a blend of gasoline and up to 10% ethanol. E85 is a blend of 85% ethanol and 15% gasoline. It can be used only in vehicles designed or converted to use E85, but these vehicles can also use regular gasoline when necessary.

- **Societal and economic benefits** — Ethanol contributes to regional economic growth and job creation, particularly in rural communities. There is great potential to capitalize on ethanol fuel because Canada has the forest resources and cropland needed to support the production of ethanol.

- **Environmental benefits** — Ethanol is a renewable fuel because it is produced from plants. Ethanol also burns more cleanly and completely than gasoline or diesel fuel. Some studies show that on a full life cycle, it can produce lower levels of carbon monoxide (CO) emissions. Ethanol reduces GHG emissions because the grain or other biomass used to make the ethanol absorbs carbon dioxide as it grows. E10 from corn produces about 3% to 4% less greenhouse gas emissions than gasoline. E10 made from wood or agricultural cellulosic materials would produce 6% to 8% less emissions than gasoline, and E85 from cellulose would produce 75% less emissions.

- **Safety** — Ethanol does not pose any more risk than gasoline or diesel fuel.

- **Vehicle performance** — there is no noticeable difference in vehicle performance when using E10 or E85. The 15% gasoline in E85 is needed to help start the engine because pure ethanol is difficult to ignite in cold weather.

**City of Hamilton Note:** ethanol is an "octane booster", so it can be blended with cheaper grades of gasoline and still deliver the same performance as gasoline with a higher octane rating.

- **Vehicle and fuel availability** — E10 is available at more than 1,000 service stations across Canada. E85 is used by some organizations that have large vehicle fleets, but it is not yet commercially available in Canada. All car manufacturers warrant their 1980 and later-model vehicles to run on E10 without any engine modification. All North American automakers make flexible-fuel vehicles that can run on E85.

- **Cost** — E10 costs the same as gasoline with an equivalent octane rating. Cost for E85 varies regionally. In some areas it can be cheaper than gasoline, and in other areas, more expensive.

- **Fuel economy** — although 10% ethanol-blended gasoline contains only 97% of the energy of pure gasoline, this is partially compensated by the improved combustion efficiency of gasoline that the added ethanol provides. Overall, use of E10 increases fuel consumption by an average of 2% over pure gasoline. Automakers
have equipped E85 vehicles with larger fuel tanks to offset the fuel's lower energy content (70% of the energy of pure gasoline). This way, the distance an E85 vehicle can travel before refueling is similar to that of a vehicle using pure gasoline.

City of Hamilton Note: Bio-fuels: The Food for Fuel Debate

Higher food prices in 2007 and 2008 are a direct result of higher energy prices for agriculture and transportation, not shortages. In fact, corn production in the U.S. produced a 10% surplus in 2007 (USDA).

Hamilton is home to the two largest biodiesel producers in Canada. BIOX Corp. and Rothsay Biodiesel combined produce about 90% of Canada’s biodiesel, totaling about 90 million litres/year. BIOX and Rothsay do not use food crops as feedstock.

Bill C-33 passed in 2008 mandates a 2 per cent renewable fuel content in diesel by 2012 in Canada. This will require 600 million litres/year of pure biodiesel. This will expand the market for oilseeds like canola and camelina, and other feedstocks such as tallow. Canada exports about 85% of its oilseed production.

Propane

Propane is a clean-burning fossil fuel, usually a by-product of natural gas production. It is compressed and then stored as a liquid when used in vehicles. It is often called LPG (liquefied petroleum gas) or auto propane.

- Societal and economic benefits — all the propane available in Canada is produced by Canadian sources, bringing economic benefits to Canadians.

- Environmental benefits — Propane burns more cleanly than gasoline or diesel fuel. The use of propane as an alternative fuel in factory-built vehicles can reduce greenhouse gas emissions by 20% in light-duty vehicles on a life-cycle basis compared with gasoline. Emissions reductions resulting from converted vehicles vary and are normally not as high as for vehicles built specifically to run on propane. Propane also contains fewer toxic and smog-forming pollutants.

- Safety — like gasoline, propane is highly combustible, but it has two safety advantages over gasoline: it must be present in higher concentrations in the air before it will ignite, and it requires a much higher temperature than gasoline to ignite. When refueling a propane vehicle, the tank must be filled to only 80% of its capacity because liquid propane expands and contracts with changes in temperature. Vehicle conversions made before 1991 may not have automatic stop-fill valves in the vehicle tank. Federal, provincial and territorial regulations spell out the safe design, manufacture, testing and installation of propane vehicles.

- Vehicle performance — there is usually no significant difference in performance between propane and gasoline vehicles.
• **Vehicle and fuel availability** — some manufacturers offer vehicles that run on propane, but conventional gasoline vehicles can also be converted to run on propane. A vehicle can be converted to run on propane alone, or to run on either propane or gasoline. There are about 3,000 retail propane outlets across the country, with a higher concentration in British Columbia, Alberta and Ontario. Many of these are operated by the major gasoline retailers, and it is usually easy to find stations that sell propane, even in smaller towns.

**City of Hamilton Note:** propane is used in some of our indoor machinery applications, including fork lifts, ice resurfacers and floor sweepers.

• **Cost** — it takes 1.36 litres of propane to travel the same distance as it takes 1 litre of gasoline. But even when this difference is factored in, propane can be about 25% to 30% cheaper than gasoline, depending on the local cost for propane. Also, because propane weighs less than gasoline, propane tanks can be made larger without affecting vehicle acceleration.

• **Fuel economy** — Propane contains 74% of the energy of pure gasoline.

**Natural gas**

Natural gas is a clean-burning fossil fuel that is extracted from the ground. Natural gas can be stored onboard a vehicle either as compressed natural gas (CNG) at 3,000 or 3,600 pounds per square inch (psi) or as liquefied natural gas (LNG) at typically 20-150 psi.

• **Societal and economic benefits** — Canada is one of the world’s largest producers of natural gas, which means less reliance on a foreign supply of energy, while creating jobs and investment opportunities in Canada.

• **Environmental benefits** — Natural gas burns more cleanly than gasoline or diesel fuel. Its use results in 60% to 90% less smog-producing pollutants and 30% to 40% less greenhouse gas emissions

• **Safety** — if handled properly, natural gas is as safe as gasoline. Natural gas must be present in higher concentrations in the air before it will ignite, and it requires a much higher temperature than gasoline to ignite. Federal, provincial and territorial regulations spell out the safe design, manufacture, testing and installation of natural gas vehicles (NGVs).

• **Vehicle performance** — there are few differences between natural gas and gasoline vehicles. If you would normally use a block heater for your gasoline vehicle in cold weather, use one for your natural gas vehicle.

• **Vehicle and fuel availability** — dedicated natural gas vehicles are designed to run on natural gas only, while dual-fuel or bi-fuel
vehicles can also run on gasoline or diesel. Since natural gas is stored in high-pressure fuel tanks, dual-fuel vehicles require two separate fueling systems, which take up passenger or cargo space. Natural gas vehicles are not produced commercially in large numbers, although conventional gasoline and diesel vehicles can be retrofitted for CNG.

- **Cost** — Natural gas costs about 30% to 40% less than gasoline, and there is no federal excise tax or provincial or territorial road taxes on natural gas as a vehicle fuel.

- **Fuel economy** — CNG contains 25% of the energy of pure gasoline, while LNG contains 66% of the energy of pure gasoline.

### City of Hamilton Note: Natural Gas Vehicles

The City currently operates 5 cargo vans, several ice resurfacers and over 90 transit buses on CNG, and operates two compressor/filling stations, one at the transit facility on Upper James Street and one at the Central Garage on Wentworth Street North. The cost of maintaining these stations has been rising, and the transit station experienced lengthy partial failures in 2008 that put full transit service at risk. There is no way to supply natural gas for our buses other than at our own filling stations. There is only a single CNG retail filling station operating in Hamilton and it is not equipped with the proper fittings to connect a bus to its fuel dispenser. The City maintains contact with the industry to find solutions for issues when they arise.

### City of Hamilton Note: Electric Vehicles

Electric vehicles (EVs) have received considerable interest as a result of the high crude oil prices experienced in 2008 and the resulting swing in consumer buying towards more fuel-efficient cars. There were about 20 companies working on production and pre-production models in 2008 (Gilbert et al). In 2009, many auto makers presented new EVs at the North American International Auto Show in Detroit.

Electric vehicles may be either battery-electric (BEV), which are supplied with power from the “grid” or local power distribution company to re-charge batteries, or plug-in hybrid electric (PHEV), a combination of a BEV with a gasoline engine that acts as a “range-extender”, i.e. the engine recharges the batteries but does not drive the wheels.

Currently, EVs are available in Canada as low-speed vehicles only. Their top speed is limited to 40 km/h and so they are not required to be designed to Canadian Motor Vehicle Safety Standards which would allow them to be used on public roads. However, the capability of manufacturing EVs that meet the CMVSS exists in other countries such as the United Kingdom, where electric delivery trucks are in service.

The major impediment to EVs is battery technology. When lead-acid batteries were replaced with nickel-compound and more recently, lithium-compound materials, they became lighter, smaller and more practical for vehicles. Battery technology is almost ready for commercial vehicle products.
General Motors recently had a road-capable BEV called the EV-1 in the United States. These are no longer in service and a new PHEV, the Chevrolet Volt, is scheduled to be available in November 2010.

Ford has announced an EV to be built in partnership with Magna in 2011, and Chrysler has announced as many as three EVs for about the same time. Nissan-Renault and BMW are also working on introducing EVs in 2010-2011.

The City has seven EVs in service. All are low-speed utility carts built by John Deere and sold under the “Gator” brand. The City continues to work with the Electric Vehicle Technology Road Map group or [evTRM](#) to advance the introduction of EVs that can replace conventional fleet vehicles.

### Electric Vehicles: Do We Have Enough Power?

Ontario Power Generation estimates it has sufficient power generation capacity to charge up to 1.5 million vehicles every day during off-peak times. (evTRM meeting 06/26/2008)

The Tennessee Valley Authority has the equivalent of 7 to 8 idle plants of unused generating capacity every night that could be used to power plug-in vehicles. (AN, 06/23/2008)

### Tactic 23. Hybrid Light-Duty Vehicles

Hybrid cars and light trucks can reduce fuel consumption by 10% to 40%.

Replacing conventional vehicles with hybrid vehicles will lead to reduced fuel consumption, fuel costs and GHG emissions.

**City of Hamilton Note:** Hamilton is an early adopter of hybrid cars, beginning with the purchase of two hybrid cars by the Transit Division in 2000. As of March 2009 there were 81 hybrid vehicles in the Central Fleet with 10 more on order. Transit has 33 hybrid vehicles. Police have four hybrid vehicles and Fire/EMS has seven hybrid vehicles, for a total fleet of 135 hybrids in service by mid-2009.

### Hybrid technology

A conventional vehicle’s engine is sized for peak power requirements, but this much power is only required during maximum acceleration (when the driver “floors it”). This peak power requirement typically amounts to less than 1% of driving time. Most driving requires as little as 10 to 20 horsepower, but during heavy acceleration or hill climbing, as much as 10 times more power might be required.

An electric motor that provides extra power when needed is added to hybrid vehicles, allowing for a much smaller, more efficient gasoline engine and improved fuel economy. Electric motors provide maximum torque at low rpm, whereas maximum torque for gasoline engines is at high rpm. Because their peak operating efficiencies are reached at different speeds, the two are an ideal match. The battery that powers the electric motor is charged by the gasoline engine and by regenerative braking (in which the polarity of the electric motor is reversed, allowing the kinetic energy of the wheels to be used to charge the battery).
Maximizing fuel efficiency gains of hybrid vehicles

- **Drive less aggressively** — Hybrid fuel economies are particularly sensitive to the effects of aggressive driving. Drivers should avoid speeding, rapid acceleration and frequent braking, and drive as smoothly as possible. See the aggressive driving section.

- **Use air conditioning sparingly** — in city driving, it is more economical to open the windows than to run the air conditioner. The air conditioner and defroster use a compressor which in turn engages the gasoline engine. See the air conditioning section.

- **Use in urban driving situations** — Hybrid vehicles offer the greatest fuel economy benefits in stop-and-go urban driving situations. Multi-vehicle households and fleets can choose to drive their hybrid accordingly to maximize savings.

City of Hamilton Note: Plug-In Hybrids

A “Plug-in Hybrid Vehicle” (PHEV) is currently only available by taking a factory-built hybrid and installing an after-market system. A123 Systems and Hymotion, an amalgamated company based in the United States, is the best-known vendor of Plug-In Conversions. The City of Toronto operates two PHEVs with the Hymotion system, funded in part by an environmental group.

Hymotion uses lithium phosphate which does not have the same risk of overheating or exploding like some other lithium technologies. There are six conversion shops in the US and 1 in Ontario.

As a plug-in option on factory-built hybrids is expected within the next year, Hamilton will not convert existing hybrids to PHEVs.
Table 9

Hybrid Candidates among Vehicles Due for Replacement 2009 – 2011 (Central Fleet only)

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Number of units</th>
<th>Estimated Additional Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional Sport Utility Vehicles</td>
<td>4</td>
<td>$20,000</td>
</tr>
<tr>
<td>By-law enforcement cars</td>
<td>12</td>
<td>$60,000</td>
</tr>
<tr>
<td>Other cars</td>
<td>5</td>
<td>$25,000</td>
</tr>
<tr>
<td>Previously-acquired Hybrid cars</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Utility pickups</td>
<td>3</td>
<td>$15,000</td>
</tr>
<tr>
<td>Forestry aerial</td>
<td>1</td>
<td>$50,000</td>
</tr>
<tr>
<td>Total replacements</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Net increase in hybrid fleet</td>
<td>21</td>
<td>$170,000</td>
</tr>
</tbody>
</table>

City of Hamilton Note: Currently available hybrid models (April 2009)
- Cadillac Escalade full hybrid sedan
- Chevrolet Malibu mild hybrid sedan
- Chevrolet Silverado/GMC Sierra full hybrid pickup truck
- Chevrolet Tahoe/GMC Yukon full hybrid utility truck
- Ford Escape full hybrid utility vehicle
- Ford Fusion full hybrid sedan
- Honda Civic mild hybrid sedan
- Honda Insight (generation 2) hybrid sedan
- Lexus full hybrid sedan and utility vehicle (3 models available)
- Nissan Altima full hybrid sedan
- Saturn Aura mild hybrid sedan
- Saturn Vue mild and full hybrid utility vehicle
- Toyota Camry full hybrid sedan
- Toyota Highlander full hybrid utility vehicle
- Toyota Prius full hybrid sedan

City of Hamilton Note: New hybrid and electric models entering the market 2009 – 2011 (partial list)

2009
- Volvo L220F hybrid large articulated wheel loader
- International 4300-series Class 6 truck diesel electric hybrid
- Peterbilt model 335 medium-heavy duty tractor (diesel/electric hybrid)
- Peterbilt model 320 heavy duty waste collection truck (diesel with hydraulic launch assist)
- Smith Newton lithium-iron phosphate battery electric delivery truck
2010
Toyota Prius (generation 3) hybrid sedan
Chevrolet Volt plug-in hybrid sedan
Nissan has announced an EV for 2010.
Chrysler has announced an EV for 2010.
Ford Transit electric commercial van
Dodge Ram hybrid pickup truck
Lexus HS 250h hybrid sedan
Hyundai hybrid sedan

2011
Saturn Vue plug-in hybrid
Ford Edge plug-in hybrid
Ford/Magna electric car
Honda CR-Z hybrid coupe
Toyota Sienna hybrid minivan

*Tactic 24. Hybrid Heavy-Duty Vehicles*
Replacing conventional heavy-duty vehicles with hybrid vehicles will cut fuel consumption.

- Heavy-duty hybrid buses can reduce fuel consumption by up to 50%.
- Emissions harmful to the environment and to human health are drastically reduced in heavy-duty hybrid trucks and buses.
- Heavy-duty hybrid vehicles are ideally suited to urban driving applications such as delivery, municipal buses, and refuse collection and utility trucks.
- If 10,000 commercial hybrids were to replace conventional vehicles for just one year, NOx emissions could be reduced by 1,700 tonnes and CO₂ emissions by 83,000 tonnes.

**Maximizing fuel efficiency gains of heavy-duty hybrid vehicles**

- **Urban drive cycle** — Heavy-duty hybrids have targeted the type of work that tends to have lower-speed, urban drive cycles with many stops and starts — the exact conditions under which hybrid vehicles are at their most efficient, by maximizing regenerative braking, including:
  - buses
  - delivery and mail trucks
  - refuse trucks
  - utility trucks

*City of Hamilton Note: Diesel-electric hybrid trucks*
When the first phase of the Green Fleet Implementation Plan was prepared in 2005, there were no diesel-electric hybrid trucks on the market. The engine technology was not an issue as diesel-electric hybrids have been used in railway locomotives and submarines since the early 20th century. Acquisition cost and battery life were seen as the main barriers.

The Hybrid Truck Users Forum (HTUF) was started in the United States in 2002 to bring a commercial hybrid truck to market. By late 2005, production had started at International Trucks to build 24 diesel-electric hybrid trucks for power utilities. These were built in partnership with Eaton Corporation and are now a regular-production model. The City of Hamilton and the City of Toronto are working on specifications for a waste collection truck that will use Eaton's hydraulic launch assist hybrid (or fluid power train) and a Peterbilt truck chassis that will significantly reduce fuel use and emissions.

Azure Dynamics is a Canadian company currently building gas-electric delivery trucks on Ford’s E-450 medium-duty truck chassis for the courier industry. Both Hamilton and Toronto are looking at possible applications for this type of truck in our fleets.

The major obstacle remains the battery, but new developments indicate commercialization on a mass scale is imminent.

Lithium ion battery supply limits the production of hybrids due to shortages of this critical component.

Lithium ion (Li-ion) batteries are lighter and more powerful than nickel-metal hydride (Ni-MH) batteries now used in hybrid vehicles such as Prius and Escape.

Johnson Controls-Saft opened the world’s first production plant for li-ion vehicle batteries in 2008 in France. Bosch and Samsung SDI have a 50-50 joint venture to make li-ion batteries, and SB LiMotive Co. Ltd. says it will have product available by 2011. Continental AG and Enax (Japan) have a joint venture. Magna Steyr plans to start production in 2009. Sanyo Electric is opening a plant in Japan in 2009. Matsushita and Toyota are building two plants.

**City of Hamilton Note: After Market Fuel Additives, Engine Modification Devices and Exhaust Treatment**

The City of Hamilton has the third largest municipal fleet in Canada’s most populous province, and is in close proximity to the City of Toronto with an even larger fleet. Both cities receive numerous solicitations every year from small/medium size entrepreneurs who have a product to sell that claims to reduce fuel consumption or emissions in vehicles. Hamilton and Toronto have been leading a group of Canadian municipal fleet managers to have these performance claims properly verified by a qualified technical resource.

The Federal government set up an agency in 1997 called ETV Canada (ETV stands for Environmental Technology Verification). ETV Canada was contacted by Hamilton’s Central Fleet in 2005 for information about hydrogen fuel injection technology and found that there was a high level of interest in working with...
municipal fleet managers to create a strong testing and verification protocol. Hamilton City Council approved a recommendation in 2005 that any after-market fuel additive or engine modification device had to be verified by ETV Canada before the City would consider using it.

Beginning with a meeting in Windsor in 2006 that included the United States Environment Protection Agency (EPA), a protocol has been created that has been reviewed by all stakeholders and is almost complete.

The technology vendors, including those with fuel additives and others with engine modification devices, initially resisted the verification process. They considered it a “forced march” but some have recognized the value of receiving a government-backed confirmation of their product’s performance.

As of this date, only one vendor with an after-market device is included on the ETV Canada list of verified technologies. This is Global Emission Systems Inc. of Markham, Ontario, which offers a catalytic converter for the types of machinery that normally do not have one (lawn mowers, generators, compressors, tractors, etc.). The City of Hamilton is currently evaluating this technology for our off-road equipment.

Group 6. Maintenance

Regular vehicle maintenance leads to improved fuel efficiency, reduced long-term maintenance costs and fewer harmful exhaust emissions.

A well-maintained vehicle is also more reliable and could be worth more when it is sold. Basic maintenance tips include:

- Maintain average fuel consumption — by tracking fuel consumption on a regular basis.
- Stick to a maintenance schedule — Preventive maintenance (PM) schedules done on time helps control breakdowns.

Tactic 25 Air Conditioning Maintenance

In North America, R134a replaced CFC-12 as the standard refrigerant in mobile air conditioners in the mid-1990s because CFC-12 damages the Earth’s ozone layer. Unlike CFC-12, R134a has no chlorine or bromine, so it is not considered an ozone depletion risk. However, it has an enormous climate change potential: 1300 times that of CO₂. Mobile air conditioning systems are designed to be sealed units, but this does not preclude occasional leaks.

City of Hamilton Note: Refrigerant

Central Fleet vehicles are maintained in compliance with regulations, including the requirement for technicians to obtain an ozone-depletion certificate.

Tactic 26 Oils and Lubricants

Newer lubricants can decrease fuel consumption by up to 5% and are most effective at improving fuel economy in cold-start, short-trip applications.
Over the last several decades, the push to improve fuel economy has resulted in lubricants that reduce engine and drive train friction more than standard lubricants.

- **Light-duty vehicles** — the viscosity of the engine oil used in the vehicle should be the lowest weight oil recommended by the vehicle manufacturer. Vehicle owners can also try the lowest recommended weight of oil with the American Petroleum Institute (API) “Starburst” or “Energy Conserving” marks. Although fuel savings may not be immediately noticeable, they should accrue over an extended time period.

- **Heavy-duty vehicles** — as with light-duty vehicles, the key for heavy-duty truck operators is to use the lowest viscosity engine oil recommended by the engine manufacturer. Also consider using an engine oil with the API CI-4 Plus mark. For drive train lubrication, heavy truck operators may want to consider using synthetic lubricants. However, the original equipment manufacturer (OEM) should be consulted before switching. The OEM will be able to provide an up-to-date recommendation on the best lubricants to use.

**City of Hamilton Note: Recycled engine oil.**

Central Fleet recycles its used engine oil using a certified manufacturer. Engine oil analysis is done to verify the proper performance of the engine oil. Recycled oil conserves the use of petroleum resources.

**Tactic 27. Tires, Heavy-Duty Vehicles**

Tire and wheel maintenance cuts fuel consumption.

Tire and wheel maintenance plays a large role in controlling rolling resistance to reduce fuel consumption and associated fuel costs and greenhouse gas emissions. By simply maintaining their vehicles according to manufacturers’ standards, operators can save fuel.

- **Tire pressure** — Operating with tire inflation pressure of each tire just 1 pound per square inch (psi) below the recommended level for the tire size and load can reduce fuel efficiency by between 0.09% and 1.0%, depending on the optimal tire pressure for an 18-wheel truck. (Range is based on a range of optimal tire pressures from 90 psi to 110 psi, with pneumatic coefficients ranging from –0.2 to –0.3, and rebound ratios between 1:10 and 3:10.)

- **Wheel alignment and balancing** — Depending on the degree, misalignment of tractor and trailer wheels can result in a 2.2% decrease in fuel economy.

**Tire pressure**

All tire and vehicle combinations are designed to operate with specific tire inflation pressures that have been optimized for the specific tire and vehicle. Vehicle operators can minimize rolling resistance and fuel consumption by
maintaining tire pressure at the levels indicated by owner’s manuals or according to load levels.

- **Verifying tire pressure** — Tire pressure should be checked as frequently as possible and readjusted, as necessary, depending on the load being carried on each axle. Tire pressure should be checked with an accurate gauge when the vehicle has not moved for three hours.

- **Automatic tire inflation systems** — Tire maintenance is expensive, so fleet managers should consider installing automatic tire inflation systems. They cost about $1,000 to $1,200, but manufacturers claim they can reduce annual tire inspection costs by $230 to $350, plus they reduce losses due to poor fuel economy.

- **Additional benefits** — maintaining proper tire pressure will increase tire life and reduce expenses. Running tires under inflated by 20% for a prolonged period of time reduces tire life by about 20%.

Operating with tire inflation pressure of each tire just 1 psi below the recommended level for the tire size and load can reduce fuel efficiency by as little as 0.09% or by as much as 1.0% depending on the optimal tire pressure for an 18-wheel truck.

### City of Hamilton note: Nitrogen

Filling tires with compressed nitrogen has been a common practice for racing cars and other high-performance vehicles for many years. It does not escape readily and prevents fuel efficiency losses resulting from under-inflated tires. A number of vendors are promoting it to fleets as a fuel saving measure.

There have been no trials or demonstration of nitrogen in municipal fleets that confirm any gains in efficiency.

### Wheel alignment and balancing

Misalignment and unbalanced wheels also increase rolling resistance and reduce fuel economy.

- **Wheel alignment** — Proper wheel alignment is designed to account for the forces acting on the wheels while the vehicle is in motion, setting them in a way that reduces impediments to moving forward. When the wheels are not properly aligned, tires tend to skid rather than roll, increasing the frictional forces between the tire and the road, which increases rolling resistance and reduces fuel economy. Wheel alignment should be checked every 130,000 to 160,000 kilometers or 12 to 18 months and adjusted as necessary.

- **Wheel balancing** — when wheels are not balanced properly, the vehicle operator must be more active in steering to maintain a straight course. This action of steering causes slight increases in
skidding, which increases rolling resistance and decreases fuel economy.

6. Putting the FLEETtool Tactics Into Action

Group 1 – Aerodynamics
Tactics 1-6
Not applicable to our fleet.

Group 2 – Components
Tactic 7 - Air conditioners will be maintained to prevent escape of refrigerant, which is a greenhouse gas, to the atmosphere.
Tactic 8 - Auxiliary power units
An APU pilot test for Police vehicles and ambulances has been initiated by the Ontario Government and implemented by Fleet Challenge Ontario, a private firm that has worked with Central Fleet and the City of Toronto Fleet Services Division on several fleet efficiency projects. Both our Police and EMS groups have been eager to participate in order to promote energy conservation.

Further introduction of auxiliary batteries appears to be warranted by the fuel savings observed on our initial six vehicles.

Tactic 9 - The use of block heaters on fleet vehicles parked outside will be reviewed with users and the Corporate Buildings section.

Tactic 10 - The use of on-board computers to monitor fuel consumption will be initially restricted to those vehicles that have them as standard original equipment. The Vancouver study will be reviewed to identify opportunities for trial of some types of “eco-meters”. Operator training will include instructions on how to use them to improve fuel efficiency.

Tactic 11 – Roof racks are not common on our vehicles and as they are permanently mounted a measure to remove them would not be practical.

Tactic 12 – Tires are being investigated to find suitable designs that reduce fuel consumption. Tires have a larger impact on long-haul highway transportation than in City operations, so changing tire specifications may not have a payback to the City.

Group 3 – Driver Behaviour
Tactic 13 – Aggressive Driving is addressed in our Professional Driver Improvement Course, a service offered by Central Fleet.

Denver’s “Driving Change” program will be presented to Clean Air Hamilton and Fleet Challenge Ontario to assess the possibility of duplicating the program in Hamilton.

Tactic 14 – Cruise Control will be restricted to those vehicles that have them as standard original equipment. Hamilton’s urban roads do not have high enough
speeds or long enough distances between traffic signals to make cruise control practical.

Tactic 15 – Idling Time, Light-Duty Vehicles
This issue is addressed in our driver training program, and is regulated by both our Corporate Policy and by a City by-law. The increasing use of hybrid vehicles will continue to reduce idling, as these engines are designed to shut down when the vehicle is stopped. Exceptions will occur when the air conditioner or defroster is turned on, or when the battery is low.

As described under Tactic 8 above, Hamilton Emergency Services and Hamilton Police Services are participating in the Fleet Challenge Ontario Police & EMS Vehicle Idling Reduction Demonstration Project (PEMS).

Tactic 16 – Idling Time, Heavy-Duty Vehicles

Tactic 17 – Speed
These issues are addressed as the engine control module (ECM) in about 248 heavy trucks in our fleet has been re-set to comply with Ontario’s speed-limiter law. Trucks are limited to 105 km/h when driving and 15 minutes maximum idling when stopped. Users will be consulted if a lower idling time can be implemented.

Tactic 18 – Winter Driving is part of our regular Professional Driver Improvement Course offered by Central Fleet.

Group 4 – Fleet Management
Tactic 19 – Driver Training is focused largely on safety and adherence to regulations for commercial vehicles. In 2008 Central Fleet introduced new training using the “Fleet Smart” material from Natural Resources Canada, which includes fuel conservation measures.

Tactic 20 – Purchasing decisions reflect the recommendations in this decision. Following the approval of Phase One of the Green Fleet Implementation Plan in 2005, the Senior Management Team encouraged all users of light-duty fleet vehicles to specify hybrid vehicles whenever a replacement was ordered. This has resulted in the hybrid vehicle fleet growing from 15 units in 2005 to 129 units in 2009.

The use of minicars such as the Smart Fortwo has brought favourable attention to the City. There is one car in Central Fleet and another in the Police fleet. In 2008, the standard engine in this car was changed from a diesel to a gasoline engine requiring premium-grade unleaded fuel. This reduces our ability to track fuel consumption as we do this through the automated fuel pump system at City bulk fuel stations, and these stations do not have additional storage tanks to provide premium-grade gasoline. Therefore the acquisition of more Smart cars is not being pursued.

Tactic 21 – Transportation Demand Management is addressed in Hamilton’s Transportation Master Plan.

Group 5 – Fuels and Technology
Tactic 22 – Alternative Fuels
Hamilton has long experience with alternative fuels, including the use of natural gas for buses and other city vehicles. Biodiesel and ethanol are in use and have created no operating problems. For the 2009 to 2011 timeframe of this report, hydrogen will not be commercially available. Ethanol for gasoline-powered vehicles and biodiesel for diesel engines will continue to be supplied through the City’s bulk fuel storage facilities. Propane will continue to be used for some indoor equipment and natural gas for the remainder of indoor equipment plus the remaining HSR buses in service. The continued use of natural gas for buses is being addressed in a separate report. Natural gas is not a sustainable option for the balance of Central Fleet vehicles.

Electric vehicles are the focus of several automotive manufacturers’ research efforts and Hamilton is actively involved in efforts to accelerate the implementation of EVs where practical and affordable.

Tactic 23 – Hybrid light-duty vehicles

Hamilton has used hybrid light-duty vehicles for 10 years. It was the leading Canadian municipal hybrid owner for many years and maintains a prominent position in the front rank of hybrid fleet users. The light-duty hybrid fleet would expand faster if any reasonably-priced pickup trucks were available. The General Motors product on offer for the 2009 model year is considered too expensive and is not being produced as a mass-market vehicle like the Ford Escape. Central Fleet will continue to replace conventional vehicles with hybrids unless a business case to not use a hybrid is approved by the General Manager of the department concerned.

Tactic 24 – Hybrid heavy-duty vehicles

Council has approved the purchase of up to three hydraulic launch-assisted hybrid waste collection trucks to implement the multi-residential Green Cart program (Report PW08106). Central Fleet is proposing one diesel-electric aerial truck for Forestry Operations during Phase 2 of the Green Fleet Implementation Plan. As pricing has not been confirmed, no commitment has been made at this time.

The Transit Division is receiving 18 more diesel-electric hybrid buses in 2009.

Group 6 – Fleet Maintenance

Tactic 25 – Air Conditioner Maintenance will be performed so as to prevent the release of air conditioning refrigerant to the atmosphere.

Tactic 26 – Lubricants will be investigated to see if additional fuel savings are possible through the use of lower viscosity oils. Hydraulic fluids that are refined from non-petroleum sources are being used now, to reduce the impact of spills on the ground, waterfowl and other aquatic life.

Tactic 27 – Tire maintenance routines are being investigated to maximize tire life and reduce additional fuel use caused by under-inflated tires and mis-aligned wheels. Nitrogen as a substitute for ordinary compressed air is not recommended.
7. Impacts on Greenhouse Gas Emissions

Phase 2 of the Green Fleet Implementation Plan includes a greatly increased number of tactics that will reduce fuel consumption, greenhouse gas emissions and other air contaminants. As the amount of fuel use and emissions for every tactic has not been established, it is not possible to offer an estimate of the reductions that will occur.

Forecasting the cost and results of using hybrids and biodiesel can be done with more confidence as we have considerable experience with both alternatives. Caution in considering the estimates as firm is required due to the economic situation that emerged in 2008 and 2009. Hybrid vehicle demand accelerated in 2008 as crude oil and retail fuel prices soared to record levels. The abrupt collapse of oil prices combined with the economic recession reversed the growth in demand for hybrids, which were predicted to be “as mainstream as minivans” by now. While there are many more hybrid models on the market now than in 2005, a significant price premium is still being paid for these vehicles. A hybrid pickup truck is still not available at an affordable price.

Additional emission reductions will occur as the number of vehicles equipped to reduce engine idling increases. These vehicles will have auxiliary heating and cooling or additional batteries to power lights and traffic-direction signs. Driver education and performance is the greatest variable factor in reducing fuel use and emissions. The effectiveness of training and leadership will be vital.

GHG Emissions (CO₂ + CH₄ + N₂O)
Die fuel use produces 2.76 kg/L
Gasoline use produces 2.43 kg/L
B5 (5% biodiesel) produces 2.64 kg/L

Emissions change from hybrid vehicles 2009-2011, assuming 7 additions per year to the number of hybrids operated in the Central Fleet: reduction of 454 metric tonnes. Emissions change from 5% biodiesel (B5), assuming no change in consumption at Wentworth yard: reduction of 504 metric tonnes.

Table 10
Outcomes of Phase 2 of the Green Fleet Implementation Plan

<table>
<thead>
<tr>
<th>Action</th>
<th>2009 Result</th>
<th>2010 Result</th>
<th>2011 Result</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hybrid GHG improvement</td>
<td>140 tonnes</td>
<td>151 tonnes</td>
<td>163 tonnes</td>
<td>454 tonnes</td>
</tr>
<tr>
<td>Biodiesel GHG improvement</td>
<td>168 tonnes</td>
<td>168 tonnes</td>
<td>168 tonnes</td>
<td>504 tonnes</td>
</tr>
</tbody>
</table>
8. Conclusion
The first Green Fleet Implementation Plan approved by Council in 2005 moved Hamilton into the front rank of green fleets. The preparation of Phase 2 maintains our position and demonstrates progress towards recognition of Hamilton as a leader in environmental and innovative excellence, and promoting the City as a great place to live, work and play. It confirms our commitment to triple-bottom line solutions through improving our economic, social and environmental well-being.

9. References
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