GREEN DRIVER TRAINING WITHIN THE CITY OF CALGARY'S MUNICIPAL FLEET: MONITORING THE IMPACT

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Introduction

Operators of municipal fleets are becoming increasingly aware of the impact their vehicles are having on the environment. The average Canadian city fleet is accountable for 5% of a municipality's total GHG emissions (Transportation Canada 2010a), and pending the size of the municipality and the services provided, this percentage can be even greater. For example, between 1990 and 2004, Calgary's municipal fleet, which comprises over 4,000 vehicles, was the second largest source of GHG emissions in the City (30%), represented 22% of the municipality's total GHG emissions (95 kt) and was the fastest growing source of internal Corporate GHG emissions (5% increase) (City of Calgary 2006).

The City of Calgary is increasing its use of alternative fuels and technologies having minimum environmental impact (i.e. hybrid and biodiesel fuelled vehicles), promoting an idling reduction policy, as well as 'right sizing' vehicles (i.e. employing the right vehicle size for the task) and utilizing preventative maintenance strategies in an effort to 'green' its municipal fleet. (City of Calgary 2009). An additional low-cost solution available that can further reduce CO_2 emissions and reduce the operating cost of the municipal fleet is eco-driver training. While municipalities can purchase the most fuel efficient vehicles available on the market, if drivers are unaware of how their driving habits influence environmental and economic sustainability, maximum fuel efficiency will not be realized. Through the adoption of eco-driver training, in conjunction with vehicle monitoring technology (VMT), this report will demonstrate the potential to successfully reduce CO_2 emissions that are generated through the operation of a fleet of municipal vehicles in the City of Calgary, Alberta.

Literature Review

Ecological, economical and safe driving (eco-driving) is a relatively new concept that was first developed and integrated into driver training courses by the German Federation of Driving Instructor Associations in the mid-1990s (Dandrea 1996). There are three key facets that govern eco-driving; (1) Smooth and gradual acceleration and deceleration by anticipating traffic flow and leaving space between the vehicle ahead; (2) Maintaining a steady speed while adhering to the posted speed limit; (3) Avoid idling by turning off the engine when not in use (Barkenbus 2010, NRCan 2009a). Automobile maintenance measures (e.g. maintaining optimum tire pressure, regular changing of air filters) are also often included in the definition of eco-driving (NRCan 2009b).

Although there are limited studies that have evaluated eco-trained drivers, the results are promising. A review for the European Conference of Ministers of Transport by the International Energy Agency (2005) found an average reduction of fuel consumption of 5% for OECD (Organization for Economic Cooperation and Development) regions. Additional studies have recorded 2% decrease in fuel consumption 12 months after corporate bus drivers were trained (Wahlberg 2007). Zarkadoula et al. (2007) noted a decrease of 18% for two bus drivers and an average decrease of 10% for all bus drivers during a post training monitoring period of two months. Beusen et al. (2009) stated average fuel consumption four months after the course fell 5%, with most drivers showing an immediate improvement in fuel consumption. This is also the only known study to detail the influence of eco-driver training on idling, which realized an average decrease of 1.5%. A pilot project in Colorado tracked the driving performance of 400 cars, finding an improvement in fuel efficiency of 10% after eco-driver training (Enviance 2009). A recent study by the City of Edmonton found that after training 800 fleet drivers, annual fuel consumption decreased 10% (approximately 200,000L of fuel per year), with a reduction in GHG emissions of 310 tonnes (Transport Canada 2010b).

Method

To quantify the potential reduction of CO_2 emissions from The City of Calgary's municipal fleet as a result of eco-driver training, a three phase research process was initiated between July and October, 2011: (1) baseline data acquisition (pre-eco-driver training), (2) behavioural intervention (eco-driver training), (3) post-training data acquisition (post-eco-driver training). To guide this research, three key objectives were formulated: Assess the effectiveness of eco-driver training within the City of Calgary fleet on (i) decreasing harmful vehicle emissions and (ii) reducing fuel consumption, as well as (iii) evaluate the difference in CO_2 emissions between gasoline and hybrid vehicles.

In-vehicle monitoring technology (CarChip®) was selected as a cost-efficient means of identifying opportunities to reduce GHG emissions and to measure the outcome of the behavioural intervention. All of the vehicles participating in this study operate within the Development & Building Approvals Business Unit. These vehicles serve as a mobile office for the site inspectors, with each vehicle equipped with laptops, printers, inverters and GPS units—all of which operate off of the vehicle's power supply. As a result, there is high potential that the vehicles within this department are idling a long period of time. A total of 15 self-selected drivers were examined in this study.

Phase I

In July 2011, The City of Calgary installed CarChips® into 15 fleet vehicles (Ford Escape—11 gasoline, 4 hybrid), plugging the device into the On-board Diagnostic port. The CarChips® then continuously read the driving and engine performance data from the vehicle's on-board computers, storing the data on an internal memory card. A description of the parameters, their units, and how each one was calculated is provided in Table 1. The baseline data acquisition concluded in August, 2011, removing the CarChips® from the vehicles, and downloading the data using a universal serial bus cable onto a netbook. DriveRight Fleet Management Software and Microsoft Excel were used to analyze and calculate the data at varying degrees of detail.

Table 1. Variables Monitored and Calculated

Parameter	Description
Number of Trips	Counted every time the vehicle's ignition is turned on, to when it is turned off – regardless of the distance travelled
Drive Time (hours)	Total time the vehicle is driven
Distance Driven (km)	Total distance travelled
Average Trip Distance (km)	Average distance travelled
Average Speed (km/h)	The average speed the vehicle travelled
Average Top Speed (km/h)	An average of the highest speed the vehicle reached in each trip
Hard Acceleration Count per 100km	Number of times the vehicle performs a speed difference of ≥30km/h in ≤2.8 seconds
Hard Deceleration Count per 100km	Number of times the vehicle performs a speed difference of ≥30km/h in ≤2.4 seconds
Idling	When the vehicle engine is turned on, but not moving (speed = 0 km/h), this includes all time spent stopped at traffic intersections.
Idling Time (hours)	Total amount of time the vehicle is idling
Percentage of Idling Time (%)	Percentage of time vehicle is idling
CO_2 Emissions from Idling (kg)	Kilograms of CO_2 emitted when the vehicle is idling[1]
Fuel Consumed from Idling (L)	Litres of fuel consumed while the vehicle is idling[2]
Fuel Cost from Idling ($CAD)	Cost of fuel consumed from idling[3]

Phase II

Based on *EcoDriver*, a course developed by Green Communities Canada, Phase II aimed to promote environmentally friendly driving habits and reduce fuel consumption and GHG emissions. A total of 6 courses were held between August and September, 2011. The *EcoDriver* curriculum was tailored for the City of Calgary by developing scenarios and examples specific to the operation of the municipality's fleet, including: trip planning; right sizing (i.e. use the size of vehicle that fulfills the travel/hauling requirements and shifting to the use of smaller vehicles); tire pressure awareness; vehicle maintenance; smarter driving style (i.e. accelerate gently, follow speed limits, anticipate traffic flow, coast to decelerate); reducing unnecessary idling; reducing warm-up times; carpooling.

Phase III

Immediately following Phase II, the post-eco-driver training data acquisition was launched to quantify the differences in driver behavior between the pre- and post-eco-driver training courses. The same method that was applied in Phase I was replicated during Phase III, such that the CarChips® were installed back into the same 15 participating vehicles, recording the same parameters (Table 1), with the removal and downloading of the data from the devices in October, 2011.

Results

Given that the engine operation of a gasoline versus a hybrid vehicle is fundamentally different (discussed further in this section), the fleet results have been divided by the two vehicle types. All of the detailed results summaries are given by parameter and include the daily average (i.e. average daily results from the sample study), annual vehicle total (i.e. total sample extrapolated to one full working year[4]) and annual department total (i.e. sample size extrapolated across the Development & Building Approvals Business Unit of 115/39 gasoline/hybrid fleet for one full working year).

Phase I

For the 11 gasoline vehicles analyzed in this study, average daily drive time was 3 hours per day, with an average total distance of 40 km per day (Table 2). Average number of daily hard acceleration and decelerations was 0.6 and 1.4, respectively. Average total idling among the sample was over 1.6 hours per day, or approximately 52% of the time the vehicles were in operation. Overall, average daily idling per gasoline vehicle leads to 5kg of CO_2 emissions and consumes approximately 2L of fuel at a price of CAD$2.82 per day.

Extrapolating the results from this sample (11 gasoline vehicles) to represent the Development & Building Approvals Business Unit total gasoline fleet (115 gasoline vehicles), it becomes highly evident that opportunities exist to improve the economic and environmental efficiency of the fleet (Table 2). Annual total hard acceleration and deceleration for the department is estimated to be over 18,700 and 43,600, respectively. Moreover, nearly 45,000 hours per year would be spent idling, which would constitute 155,000kg of CO_2 emissions and consume over 67,000L of fuel at a cost of CAD$81,000.

Average daily drive time for the 4 hybrid fleet vehicles during Phase I was half that of the gasoline sample (1.5 versus 3 hours per day), but the distance driven by the hybrid drivers was similar to that of the gasoline drivers (35 and 39km, respectively) (Table 2). This is because the CarChip® only records data when the gasoline engine is engaged, not when the battery (i.e. electric motor) is engaged. The hybrid vehicle is not required to rely solely on the gasoline engine since it has an alternate power source—an electric motor and batteries. As a result, a hybrid vehicle is able to turn off the gasoline engine while the vehicle is in operation, subsequently disabling the CarChip®'s ability to record driving behaviour. This is also likely why daily average hard deceleration counts (1) were lower for the hybrid sample than the gasoline sample, because as the Escape hybrid decelerates, it does so under electric power once the engine reaches approximately 40kph (Grabianowski 2005). Hard accelerations were however slightly higher within the hybrid fleet sample (1.1 counts).

In terms of idling, the hybrid vehicles idled for approximately 1 hour less than the gasoline vehicles (0.5 versus 1.7 hours) or approximately 36% of the time the hybrid vehicle was turned on (Table 2). This lower idling can be partially explained by the fact that when the hybrid is turned on but stopped (e.g., at a stop sign/lights, traffic), the gasoline engine will shut-off, leaving the electric motor to run—thereby disabling the CarChip® from data acquisition. Idling is nevertheless evident, which is likely the result of the drivers running office equipment (e.g. laptop, printer) and/or temperature controls (e.g. air conditioning), which would require the gasoline engine to be in operation (Grabianowski 2005).

Table 2. Phase I Fleet Results

	Gasoline		Hybrid	
Driving Parameter	Daily Avg/ Vehicle	Annual total for 115 vehicles (250 days)	Daily Avg/ Vehicle	Annual total for 39 vehicles (250 days)
Drive Time (hours)	3.00	86,308.13	1.51*	14,709.64
Distance (km)	39.83	1,145,085.02	34.48	336,182.03
Hard Acceleration Count per Day	0.59	17027.12	1.11	10,835.00
Hard Deceleration Count per Day	1.38	39698.43	0.99	9,629.86
Idle Time (hours)	1.56	44,858.25	0.54	5,231.60
Idle Time (%)	52	-	36	-
CO2 Emissions from Idling (kg)	5.38	154,532.83	1.39	13,548.23
Fuel Consumed from Idling (L)	2.35	67,511.06	0.61	5,918.84
Fuel Costs from Idling ($1.20/ L)	$2.82	$81,013.28	$0.73	$7,102.61

* CarChip® is only able to record data when the gasoline engine is engaged, not when the battery (i.e. electric motor) is engaged.

Phase II

Based on Phase I results, a variety of behavioural changes can be targeted through eco-driver training to both decrease climate altering vehicle emissions and reduce the operating cost of the fleet. The high number of hard accelerations and decelerations recorded in the baseline acquisition can be responsible for an increase in fuel use by approximately 33-40% when compared to vehicles driven with smooth and gradual acceleration and decelerations (e.g. Ericsson 2001, NRCan 2009b, Saboohi & Farzaneh 2009, Thew 2007). Unfortunately the CarChip® is unable to capture the precise data on the speed and time difference at which a hard acceleration or deceleration incident occurs, which renders the calculation of the specific fuel consumption and CO_2 emissions that result from the incidents. Value nevertheless remains in identifying the frequency of their occurrence as behavioural changes can target the reduction of these events.

Achieving zero kilometers per liter of gas, idling is the most inefficient use of fuel identifed in Phase I. With over one-third of the time that the fleet vehicle are in operation spent idling, tens of thousands of kilograms of CO_2 are being emitted, in addition to thousands of dollars lost in unnecessary fuel consumption. This inefficiency can be avoided by simply turning off the engine when the car is not in use. In fact, more than 10 seconds of idling consumes more fuel than would have been used if the engine was turned off and restarted (NRCan 2009b). Individual driving behaviour cannot afford to be neglected, particularly when the collective contributions of the department are so large.

Phase III

When comparing the baseline data acquisition with the post-training data acquisition, positive behavioural changes are evident in both the gasoline and hybrid sample (Table 3). For the gasoline sample, hard decelerations decreased by 2.3 counts per vehicle per day. Moreover, average daily idling time decreased by 0.3 hours, thereby reducing CO_2 emissions by 1.1kg and fuel consumption by 0.48L (or CAD$0.58) per vehicle from idling. Once extrapolated, eco-driver training would result in annual department reductions of nearly 33,000 hard decelerations. It would also eliminate almost 10,000 hours in unnecessary idling, decreasing CO_2 emissions by almost 32,000kg, thereby consuming almost 14,000L less in fuel, saving over CAD$16,000 per year (or approximately 25% of the total fuel consumed by idling).

However, not all parameters among the gasoline sample were positively influenced by the behavioural intervention. Hard acceleration increased an average of one count per vehicle per day, along with a 1% increase in idling during the first trip of the day. The former may be the result of collecting data in different seasons for the pre- and post-eco-driver training phase (summer versus fall). During the Phase III, data acquisition occurred in October, a time period in which the roads may be more congested as families return to Calgary after summer vacations and children return to school. While this may provide some justification for the slight increase, it is nevertheless a continued opportunity to target this inefficient driving behaviour and push for change among fleet drivers. The latter parameter may actually not be an increase at all, but rather only appear to be an increase. That is, since overall idling decreased by 4% from Phase I to Phase III, the percentage of idling time that occurs during each vehicle trip in Phase III becomes concentrated.

For the hybrid sample, average daily idling time decreased by 0.3 hours per vehicle, thereby reducing CO_2 emissions by 0.6kg and fuel consumption by 0.3L or CAD$0.30 per vehicle per day (Table 3). Once extrapolated, eco-driver training would result in annual department reductions of over 3,000 hours in unnecessary idling, decreasing CO_2 emissions by over 5,000kg and thereby consuming more than 2,000L less in fuel, saving nearly CAD$3,000 per year (a 75% savings).

Similar to the results of the gasoline fleet vehicles, not all parameters among the hybrid sample were positively influenced by the behavioural intervention. Daily average hard acceleration and deceleration counts both marginally increased from the baseline data acquisition (0.1 and 0.4, respectively). However, these parameters may not have actually increased, but rather appear to have increased because the parameters are concentrated as a result of the decrease in average daily drive time and average distance per vehicle from Phase I to Phase III (0.7 and 13, respectively).

Table 3. Phase III Fleet Results

Behaviour Change (Pre- to Post-Training)				
	Gasoline		Hybrid	
Driving Parameter	Daily Avg/ Vehicle	Annual total for 115 vehicles (250 days)	Daily Avg/ Vehicle	Annual total for 39 vehicles (250 days)
Drive Time (hours)	-0.45	-12,867	-0.70	-6,844
Distance (km)	-3.10	-89,022	-13.26	-129,289
Hard Acceleration Count per Day	+0.10	+2,969	+0.02	+241
Hard Deceleration Count per Day	-0.21	-5,943	+0.10	+971
Idle Time (hours)	-0.34	-9,873	-0.33	-3185
Idle Time (%)	-4	-	-10%	-
CO2 Emissions from Idling (kg)	-1.10	-31,749	-0.57	-5,513
Fuel Consumed from Idling (L)	-0.48	-13,870	-0.25	-2,408
Fuel Costs from Idling ($1.20/ L)	-$0.58	-$16,644	-$0.30	-$2,890

Discussion

An assessment of the effectiveness of behavioural intervention reveals positive results, with the sample of vehicles realizing a reduction in average daily idling, and the gasoline vehicles achieving a reduction in average daily hard deceleration counts. Eco-driver training therefore lead to the successful reduction in harmful daily CO_2 emissions and a decrease in average daily fuel consumption (research objectives 1 and 2).

The results of this study also underscore the benefits of driving a hybrid vehicle (research objective 3). As shown in Table 2, gasoline and hybrid drivers within the department drive similar average daily distances, but the hybrid drivers are only using a fraction of the fuel. Based on the results from this study, 10 hybrid vehicles over the course of the year would translates into a difference of nearly 10,000kg of CO_2 emissions and over $5,000 in fuel per year (or approximately 4,000L less in fuel consumption) when compared to 10 gasoline drivers.

Having an eco-trained hybrid driver further enhances these benefits. Based on the results from this study (Table 3), 10 eco-trained hybrid drivers, when compared to 10 untrained eco-drivers, would further reduce CO_2 emissions by more than 1,400kg per year, saving over 600L of fuel, or approximately $750 per year. In essence, eco-driving styles are essential to maximize the economic and environmental benefits of hybrid vehicles due to the ability of eco-driving to optimize the use of the electric motor over the gasoline motor.

Perhaps the greatest challenge moving forward will be to ensure the effectiveness of the behavioural intervention continues. In a follow-up survey (distributed via email approximately one month after drivers took the eco-driver course), participants re-confirmed their commitment, suggesting that positive behavioural changes will continue to be realized. For example 55% reported that they regularly practiced gentle accelerations, 64% reporting reduced speeds on the highways, 60% reporting that they coasted to a stop, 58% reporting that they combined trips at work.

Nevertheless, previous studies have shown that the positive effects of eco-driver training can diminish in the weeks and months following the completion of the course, with drivers relapsing into their older (inefficient) driving habits (e.g. Civitas 2008, Beusen et al. 2009, Barkenbus 2010). The degree to which the positive effects of eco-driving are retained is relatively unknown, with no known studies that conclusively document the average rate and degree of reduced effects among eco-driver participants. One recent exception is a study by the Quebec Ministry of Natural Resources (2011). Among the drivers that had been trained, up to 56% applied eco-driving techniques in the first month after training, which remained stable for approximately 6 months before half of the drivers abandoned their new driving habits by month 9 (reducing the application of eco-driving techniques to just under 20%).

To ensure the effectiveness of the behavioural intervention is maintained, the initial eco-driver training should be complimented through the provision of periodic review sessions for the drivers. Efficient driving behaviours could also be reinforced through performance feedback (e.g. installing ScanGuages into the vehicle) or incentives (e.g. monetary incentive such as offering a portion of savings garnered through the reduction of daily fuel consumption). Motivated drivers with a form of reminder or incentive will tend to retain the positive effects of eco-driving when compared to those drivers who have no form of incentive at all (Civitas 2008, Barkenbus 2010).

Limitations

There are three key limitations as they are applied in this study. The first relates to the inability of the CarChip® to record all driving behavior in the hybrid vehicles, such as when the electric motor is engaged. The second limitation relates to the CarChips® inability to calculate specific fuel consumption and CO_2 emissions for the parameters of hard acceleration and hard deceleration counts. The third limitation relates to idling. There are a few circumstances in which individuals may be required to idle their vehicle. This includes to warm the engine, to warm (heat) or cool (air condition) the interior of the vehicle, to wait for something unrelated to traffic (e.g., a passenger), and while commuting (e.g., at a stop sign, traffic lights, railway crossing) (Carrico et al 2009). This latter idling circumstance is difficult to avoid for functional and safety purposes and can therefore be deemed necessary idling and should not be included in the daily average and total idling time. Unfortunately the CarChip® quantified idling at every point when a vehicle was at zero kilometers per hour. Ideally, second by second data could be collected to calculate those circumstances when the vehicle is idling for 60[5] seconds or less as necessary idling, thereby removing these circumstances from the daily averages and totals. To do so would demand high memory space on the CarChip®, thereby requiring regular (i.e. weekly) data downloads. Unfortunately, to access the CarChips® during the study period required the City staff to request access through the fleet management department, requiring the vehicle to be taken off the road to uninstall, download and then reinstall the device—a time consuming and a logistically difficult procedure.

Conclusion

A primary challenge among Canadian municipalities such as The City of Calgary, is to identify the sources of GHG emissions that have the greatest capacity for substantial reductions, while simultaneously planning and implementing means to achieve reduction goals. The current debate predominately focuses on the use of economic regulation (e.g. carbon taxation, cap and trade systems) within industry sectors, including transportation. While such regulatory measures may be critical to achieving such goals on a much larger scale (e.g., nationally and globally), recent studies have indicated that necessary CO_2 reductions can be achieved locally through a number of relatively simple behavioural modifications on an individual level. This study lends support to this assertion, demonstrating that eco-driver training can be a cost-effective fleet management practice for The City of Calgary that can and has reduced climate altering greenhouse gases, while simultaneously saving money and improving the livability of the city. Best practices from this project can be used as a model for additional municipalities, as well as other operations with large fleets of vehicles, with the aim of reducing GHG emissions related to transportation across Canada.

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Endnotes

[1] 2.289 kg/CO_2/L of gas (Environment Canada, 2008).
[2] Idling time*fuel flow*60, with fuel flow = engine size* 0.6 / 60 (Environment Canada, 2008).
[3] Fuel consumed from idling*price of fuel (CAD$1.20/L).
[4] Defined as five working days per week multiplied by 50 working weeks.
[5] Idling for 60 seconds or greater has been identified by NRCan as unnecessary idling (NRCan 2008).