# Fleet Vehicle Idling – Are Supplemental Hybrid Idling Reduction Systems the Answer?

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## ABSTRACT

Environmental concerns and rising fuel costs are driving Ontario's municipalities and fleet operators to consider alternative vehicle technologies. Extended fuel consumption and air emissions are attributed to the unique operations of fleet vehicles and in particular, during idling. While drivers of passenger vehicles may have the option of simply not idling, fleet and emergency vehicle operators, may need to keep the vehicle operating to supply power to critical onboard equipment. These demands may be exacerbated during seasonal, temperature extremes. However, prolonged idling can impose significant environmental and economic burdens. Hybrid vehicles have yet to be utilized widely by Ontario's fleets, but there are other approaches to reduce emissions, including alternative "green" technologies to operate in-vehicle equipment and maintain fleet vehicle capabilities instead of idling. **Fleet Challenge (FC)** embarked on several innovative initiatives to develop and implement a supplementary *Hybrid Idling Reduction System (HIRS)* to reduce the impacts from idling of fleet vehicles, and in particular police and EMS (PEMS) vehicles. The objective of the PEMS project was to demonstrate that the technology will lower idling, reduce fuel consumption, lower emissions and payback the incremental cost over the vehicle life cycle.

## KEYWORDS

LCA, feet vehicles, hybrid vehicles, idling, fuel consumption, green technologies

## 1.0 INTRODUCTION

Mobile sources (cars and trucks) are major contributors to air pollution in metropolitan cities **[1].** According to Natural Resources Canada the transportation sector accounts for almost 30% of the GHG emissions in Canada, and globally, the transportation sector contributes for one fourth of GHGs and air pollutants **[2].** With the increase in population, the number of vehicles on the road has correspondingly increased. Hybrid vehicles are considered a preferred alternative to internal combustion engine vehicles because they are reported to reduce air emissions and fuel consumption while remaining competitive in performance with conventional vehicles in urban or commuter usage scenarios. They have the potential to address environmental, economical and social issues associated with ICEVs (internal combustion engine vehicles) **[3].** In the last four decades there have been rapid developments in the hybrid vehicle technology, and in particular gasoline-electric powertrains. There are several benefits attributed to the use of HEVs particularly in common, urban travel scenarios:

1. Greater fuel efficiency than conventional gasoline cars;
2. Substantial emission reduction;
3. Reduced operating cost due to lower fuel consumption;
4. Potential for the vehicle-to-grid technology to harness stored energy;
5. Potential to enable changes in driving habits and attitudes;
6. Reduced health costs due to the improvement of air quality.

While these benefits cannot be realized in every operating scenario, HEVs can provide tangible economic and pollution control benefits in specific scenarios and furthermore, can provide potential significant and broad-based environmental, health, and socio-economic benefits. Hybrid vehicles can also be employed for some fleet activities, such as taxis or small-scale delivery vehicles, but their effectiveness can vary tremendously depending on the fleet needs.

A number of fleets have unique operational cycles. Fleet vehicles such as emergency services, delivery vehicles, maintenance vehicles contribute to greenhouse gas (GHG) emissions from extended fuel consumption due to specialized demands. In particular, fleets composing mainly of emergency response units often need to idle the most. For example, police and EMS vehicles can spend up to 70% of their in-service time simply idling to provide electrical power for on-board systems as well as heating and cooling for the passenger compartment. Environmental concerns about emissions and rising fuel costs are driving fleet operators to consider alternative technologies. Currently, work is being done with existing technologies to develop and test an innovative device that not only stops idling, but also provides for all on-board systems to continue operating. Alternative electric subsystems and controls, or auxiliary power units that still use conventional fuels but on a much smaller scale, could offer significant benefits to fleet vehicles, such as by powering electronics while reducing or eliminating the need for conventional engine operation. Such technologies or modifications that offset conventional fuel usage will be termed ***assistive technologies***.

However, there are important issues to resolve in relation to assistive technologies. Do they actually provide justifiable benefits? While such technologies might make intuitive sense, fleet vehicles endure specific and unique duty cycles (e.g., idling, stop and go, extended distances, sudden accelerations, etc.) that may render such assistive technologies less than effective. Life cycle assessment (LCA) can be used to assess their benefits and impacts.

The benefit of LCA to evaluate environmental impacts of transportation systems has been discussed by Stanciulescu and Fleming **[4]**. For light-duty vehicles of different fuel/power train combinations it was found that most of the GHG emissions occur during the vehicle operation stage for reformed gasoline ICE and hybrid types. The same can be said for diesel and diesel hybrids. However, in both gasoline and diesel cases the hybrid alternative has lower GHG emissions during the operation stage. Overall out of these four scenarios, it is the diesel hybrid that yields the lowest GHG emissions in g $CO_2$eq/km **[4].**

This research assessed the sustainability of selected assistive vehicle technologies for representative police and EMS fleet vehicles in Ontario using an LCA approach. The LCA examined the possible trade-offs of integrating specific assistive technologies (e.g., electric subsystems, auxiliary power units) that can supplement energy production on conventional vehicles.

## 2.0 MATERIALS AND METHODS

To undertake the research, a variety of assistive technologies were implemented to determine how they can offset the impacts and costs associated with idling. These technologies included:

- Ford Crown Victoria **Urban Police (UP)** (gasoline)
    - stop idle device
    - auxiliary battery
    - gas fired heater
    - 12 volt A/C compressor
- Ford Crown Victoria **Rural Police (RP)** (gasoline)
    - stop idle device
    - auxiliary battery
    - gas fired heater
    - 12 volt A/C compressor
- Ford E-350 with Demers **Ambulance Body (EMS)** (diesel)
    - Auxiliary power unit (APU) to support electrical loads and heating and cooling requirements

### 2.1 Police Vehicles Rural Police (RP) and Urban Police (UP)

**Auxiliary Batteries**: In the RP car, one deep cycle lead acid traction battery was installed on the right (passenger) side of the vehicle using brackets designed and built specifically for this purpose. In the UP car, a purpose built battery pack was mounted transversely across the trunk. Police electrical loads including emergency lights, radio, and computer equipment, were powered by the battery. The battery also powers an auxiliary heater and air conditioner as described below. The battery is recharged when the car engine is on or with shore power using an onboard battery smart charger. The battery is connected to the OEM starting battery with a separator set up so that the starting battery is always charged first to ensure there is always power to start the vehicle engine.

**Auxiliary Heater**: A gas fired auxiliary heater was installed at the front of the vehicle in the engine compartment under the OEM starting battery. It supplies heat when the engine is not in operation. The auxiliary heater draws fuel from the vehicle fuel tank to heat the vehicle engine coolant.

Heat produced by the auxiliary heater is introduced to the passenger area via the OEM heater ducts and blower fan to ensure simple operation, similar in operation to the OEM heater. The heater provides an additional benefit in that it keeps the vehicle's engine warm during cold weather ensuring easy starting in the coldest conditions.

**Auxiliary Air Conditioning**: A 12 V DC A/C compressor was installed in the trunk to supply cooling to the passenger compartment when the engine is not in operation. The unit operates in parallel to the OEM A/C compressor. The 12 V DC compressor is connected to the OEM refrigerant lines with a solenoid valve so that when the engine is off, cooling is provided with electrical power.

**Stop Idle Device (SID)**: This device is used to control engine idling as well as cabin temperature. The stop idle device only works when the engine has reached normal operating temperature (determined by engine idling RPM) and with the vehicle transmission in Park. The SID will allow the engine to idle for 3 minutes and then shut the engine off. The SID then monitors auxiliary and OEM battery voltages as well as cabin temperatures. If the voltages drop below a predetermined threshold the SID will restart the vehicle engine. The engine then runs for 30 minutes to recharge the batteries and turns of the vehicle engine again. The stop idle also maintains cab temperature within a preset range by operating the auxiliary heater or air conditioner as required.

## 2.2 EMS Diesel Vehicles

**Auxiliary Power Unit:** EMS vehicles run the vehicle engine to provide heat/AC and to power a second alternator to support electrical loads. For the EMS portion of this project, an APU typically used in the trucking industry was re-engineered to fit into a compartment normally used to carry a spare tire. Significant modifications were made to the APU for engine cooling and sound-proofing. The APU powers an alternator to support EMS electrical loads and drives an A/C compressor for air conditioning. Energy from the APU engine coolant is used for heating. The APU controller automatically turns off the vehicle after the transmission is placed in park and the engine has idled for 3 minutes. If the APU controller senses a need for electrical power, heat or air conditioning, it starts the APU engine automatically.

## 2.3 Assessment Approach

Life cycle assessment (LCA) techniques quantify the aggregate environmental impact of a product or process by identifying the life cycle stages with more severe environmental impacts and quantifying trade-offs between alternatives **[5,6].** LCAs are significant undertakings however, and three challenges that have impeded the easy use of LCAs are:

1) the resource-intensive data collection processes required;
2) the sheer volume of information potentially accessible; and,
3) the uncertainties associated with applying site-specific reference data to processes at a different facility or manufacturing scenario **[7, 8].**

While substantial research has been conducted on the performance of vehicles using different power trains and energy sources, there is significantly less available research on the life cycle environmental trade-offs for fleet vehicles, especially when considering their unique modes of operation and the innovative technologies required for operational purposes. Important methodological issues include:

- The current move to alternative electric systems requires significantly more battery capacity and new energy storage technologies. However, battery performance under the unique fleet operation scenarios is not known with certainty. Also, the disposal and recycle or recovery at the end-of-life poses environmental issues that are not yet well understood or quantified.
- The overall ‘behaviour’ of the fleet must be considered. For example, the performance of technologies to reduce emissions are usually first estimated from idealized vehicle use

conditions. However, individual operators of vehicles will exhibit different driving and vehicle use patterns that may bear little resemblance to these test situations, and thus can reduce the applicability of the data.

- The obsolescence of the vehicle is studied in terms of the life cycle analysis. For example, would it be worth the cost and resources of implementing idling reduction technologies that produce significant environmental benefits if the fleet vehicles are only used for a short time span due to wear and tear through regular use and/or a frequent replacement cycle?

The innovativeness of the approach followed on this project refers to both the innovative technologies employed in this project as well as the use of the modified LCA to assess them. The research complied with relevant LCA protocols and referenced Life Cycle Inventory (LCI) data collection tools **[9].** To address the data challenges in an LCA, fleet and research experts were consulted to assess what are the *priority areas of study* with reference to the alternative technologies currently and potentially to be deployed.

Even though each stage of a vehicle life cycle should be environmentally analyzed, it is not always feasible or practical to conduct a complete LCA. The goal and scope of the LCA is determined in relation to the intended application of the research. In this study the goal was to compare conventional fleet vehicles with and without the HIRS assistive technologies. The scope was to study the assistive technologies only during the usage phase. The system boundaries for this study are indicated with the green box in **Figure 1**.

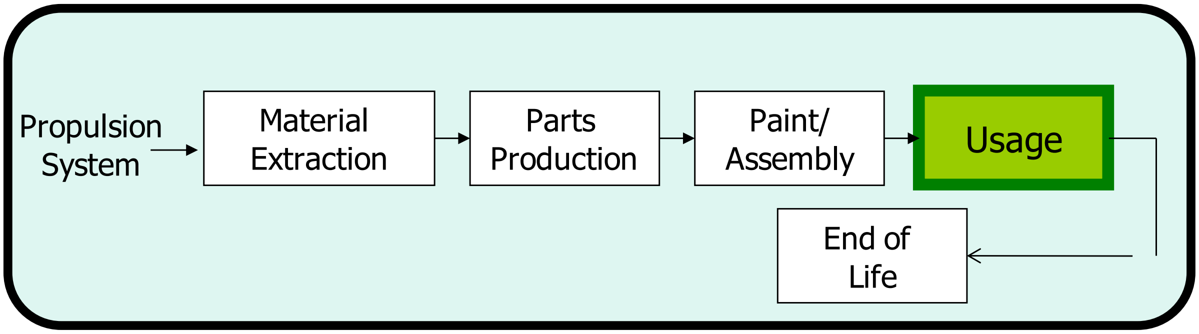

**Figure 1. Life Cycle Stages of a Vehicle**

The ***functional unit*** is an essential element of the LCA and should be defined at the start of the project. The inputs and outputs of a system under study can be related through the functional unit and also it allows the comparison between products or processes under investigation. The functional unit suggested for this research is: ***per 1 hr idling***.

## 2.4 Data Collection

After determining the goal, scope and functional unit of the project, the next step was to collect the data and any other relevant information needed for the analysis. This is the life cycle inventory (LCI) stage of the LCA, and is generally the most time consuming stage. Assumptions if data was not available or if the accuracy of the available data was not known. The data inventory for this research is outlined below.

- Tests for UP, RP and EMS were performed at different temperature scenarios in a fully enclosed environmental chamber capable of testing entire vehicles to determine the performance of HIRS as well as potential fuel savings.
- Idle baseline data from Toronto EMS and Simcoe County EMS. Data about fuel consumption and idling time was collected from several EMS units within one year time span (data not included here)
- Idling baseline data for 6 UP and 6 RP vehicles without HIRS from on board data loggers (CrossChasm[a]) giving in-service performance at different temperatures. Data were collected in August 2010, September 2010, January 2011, February 2011 and March 2011. To include a wide range of temperatures, more idling baseline data for 1 UP and 3 RP vehicles without HIRS and for 5 EMS vehicles without APU were collected from on board data loggers (CrossChasm) in June, July and August 2011. The data collected from these vehicles formed the baseline information that was used to compare the performance of HIRS.
- Idling data from 1 UP HIRS vehicle and 1 RP HIRS vehicle from onboard data loggers (CrossChasm) giving in service performance at different temperatures. The data was collected in February 2011 and March 2011. In addition, data for 1 RP HIRS vehicle were collected from onboard data loggers (CrossChasm) in the months of June, July and August 2011.
- Idling data from 1 UP HIRS vehicle and 1 RP HIRS vehicle from onboard telematics device (AutoVision Wireless[b]) giving in service performance. Although telematics idling data were not directly used on the analysis, it was used as a backup compare the information collected from the on board data loggers.
- Ontario temperature data to establish typical climate conditions.
- Electricity use to charge the auxiliary battery.
- Battery duty cycles on UP (Energy Xtreme[c] power cell) and RP (Discover[d]) using battery data loggers.
- Heater and air conditioning specifications

## 3.0 RESULTS AND DISCUSION

### 3.1 Data Analysis

The data collected during the LCI stage were analyzed in order to quantify the environmental outcomes of the technologies studied. The LCA involved several scenarios based on climate region and vehicle operation stage. Based on the climate data collected from the Environment Canada National Climate Data and Archive Information, three general scenarios were considered: winter, summer, and shoulder seasons. The average temperatures for the three scenarios are summarized in **Table 1**. Values reported in **Table 1** were calculated using climate data from several regions in Ontario and assigning a weighting percentage to each region (data not shown here). However, average temperatures are not representative of regions in Ontario where the temperatures in winter could drop to -35°C and in summer could rise to +35°C for different periods of time. The battery capacity and life are heavily dependent on the battery temperature. In order to account for those extreme conditions and increase the validity of the results the climate scenarios will be extended to temperatures ranges summarized in **Table 2.** Tests with the UP, RP and EMS were performed

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a.ChrossChasm Technologies, www.chrosschasm.com
b. Autovision Wireless, http://www.autovisionwireless.com
c. Energy Xtreme, http://www.energyxtreme.net/
d. Discover Energy Corporation, http://www.discover-energy.com/

at these temperatures ranges and compared against the data collected in the in-service performance (i.e. data loggers and telematics).

**Table 1. Climate Scenarios**

| Season | Winter | Shoulder | Summer |
|---|---|---|---|
| Temperature Range [°C ] | - 25 to + 10 | +10 to +25 | +25 to + 35 |

**Table 2. Extended Temperature Scenarios**

| Season | Winter | Shoulder | Summer |
|---|---|---|---|
| Temperature Range [°C ] | - 25 to + 10 | +10 to +25 | +25 to + 35 |

The baseline percent idling time **(Table 3)** was calculated using the data collected from on board data loggers (CrossChasm) that tracked the idling of RP, UP and EMS vehicles. From **Figure 2** it can be seen that percent idling for the UP is slightly higher than for RP, which could be related to the different functions of these two fleets. Nevertheless, the percent idling is substantial for both fleets. Similar results for baseline idling were observed in other tests (data omitted to avoid redundancy).

**Table 3. Assumptions for UP, RP and EMS Calculations**

| | **RP** | **UP** | **EMS** |
|---|---|---|---|
| hr/shift[1] | 10 | 12 | 12 |
| shifts/day[1] | 2 | 2 | 2 |
| **Baseline Idling** | | | |
| % idling [Annual] | 57% | 61% | 29.5% |
| % idling [winter] | 61% | 60% | |
| % idling [summer] | 54% | 61% | |
| % idling [shoulder] | 51% | 63% | |
| **Idling with HIRS** | | | |
| *Best Case* idling all seasons [%] | 5% | 5% | N/A |
| *Field results* idling all seasons [%] | 39% | 32% | |
| Fuel Carbon Intensity [kg/year] | 2.4[2] | 2.4[2] | 2.6[3] |
| Vehicle Utilization Factor [%] | 25%,50%,75% | 25%, 50%, 75% | 25%, 50%,75% |

[1] Based on current operating practices of feet and % idling obtained from field data

[2] Gasoline

[3] Diesel

In vehicles with HIRS installed, idling should be almost eliminated in some seasons with the exception of the 3 minute interval for the stop idle device to turn off the vehicle engine. Although idling was reduced significantly it was still higher than expected. There are also discrepancies in measured data where idling varied within the same ambient temperature range.

There could be many reasons for higher idling than expected and the discrepancy in data. One primary reason considered to have the most impact is the operator's behaviour. In tracking the vehicle operation through Autovision's telematics, it was found that on many occasions the RP stop idle device was turned off by the driver. Driver behaviour will be discussed further in Section 3.2. Other reasons that were thought to have an impact on inconsistent idling results were: shore power not plugged in to recharge auxiliary batteries; possible parasitic electrical loads draining the auxiliary battery; and problems with the UP vehicle where the laptop communications were interrupted which required the officer to restart the car in order to re-establish connectivity. As a result, the percent idling reduction is understated and could be higher if these conditions are mitigated.

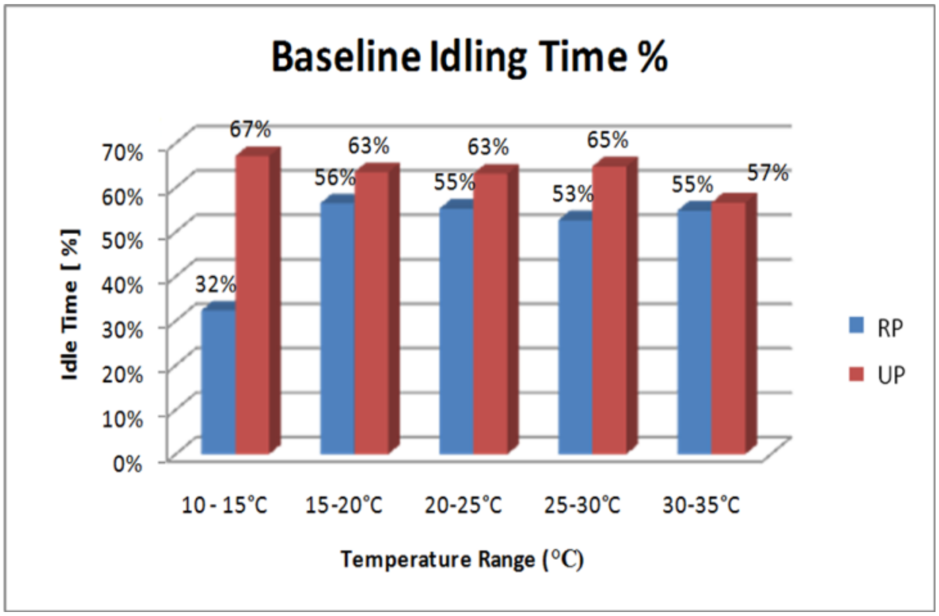

**Figure 2. Police Idling Time % vs. Temperature Range from Aug-Sept 2010 Testing**

To overcome these issues it was decided to perform the analysis by considering a ***best case*** and a ***field results*** scenario **(Table 3)**. Under the ***best case scenario*** it was assumed that the vehicle with HIRS would idle 5% of the operation time. This value is similar to a regular passenger vehicle which, as reported by GW Taylor Consulting **[10]** for long duration idling (over 5 minutes), is between 3% to 4% and is an achievable target if HIRS is fine tuned as a commercial product. Calculations using this value will indicate potential performance and savings for vehicles that have implemented the HIRS technology. The percent idling selected for the field results scenario for UP is 32% and for RP 39 %. These values are the overall idling percentages from field testing. However, it should be noted that for specific calculations, more field data are necessary to ensure statistical validity. For the EMS the measured 29.5% idling was used for all the calculations.

Vehicle utilization which is the amount of time the vehicle is used expressed as percentage, was considered in analysis. It was found that vehicle utilization is not 100%. Field data indicated that UP, RP and EMS vehicles have a utilization ranging between 11 to 47%. Since fleets in different regions have different utilization rates, the analysis used 25%, 50% and 75% vehicle utilization rates. Assuming that data are normally distributed, the results calculated using the first, second, and third quartiles will be useful in representing the fleet population, and at the very least, providing consistent benchmarkers.

Fuel consumption at idle was measured using precision flow meters. The value for the annual fuel consumption is calculated by taking the average of idling fuel consumption for all temperatures tested. The same procedure was followed for other seasonal scenarios. The values are summarized in **Table 4.**

**Table 4. Fuel Consumption during Idling**

| | RP [L/idling hr] | UP [L/idling hr] | EMS_Main Engine [L/idling hr] | EMS_APU [L/idling hr] |
|---|---|---|---|---|
| **Annual** | 3.05 | 2.57 | 3.32 | 1.22 |
| **Winter** | 3.58 | 2.81 | 3.09 | 1.04 |
| **Summer** | 2.79 | 2.59 | 4.09 | 1.76 |
| **Shoulder** | 2.25 | 2.08 | 3.00 | 1.06 |

In contrast to RP and UP vehicles, the EMS with APU has two fuel consumption calculations: one for the main engine, and one for the APU. Fuel consumption for the EMS and APU are shown in **Table 4**. The value obtained from measurements was 1.3 L/hr idling for the APU and 3.32 L/hr idling for the main engine. The amount of fuel saved per each hour of idle is the difference between the amount of fuel used by main engine with the amount used by the APU (3.3 – 1.3 L/hr idling). The diesel carbon intensity is estimated at 2.6 kg/L. In contrast to RP and UP, the percent idling for the EMS was kept the same for all seasons at 29.5%. The annual calculations are based on 360 days, while the summer, winter and shoulder season calculations are based on 90, 90, and 180 days respectively.

**Figure 3** illustrates percent idling fuel consumption reduction at different seasonal scenarios. The same results were true for all three vehicle utilization rates since these are calculated values. The same trends and percentages illustrated in **Figure 3** were observed for the GHGs emissions reductions as well. The graph was omitted to avoid redundancy. Idling fuel consumption reduction ranges from 24% to 32% for RP and 47% to 49% for UP in the field results scenario. For the best case scenario values ranged from 90% to 92for RP and 92% for UP.

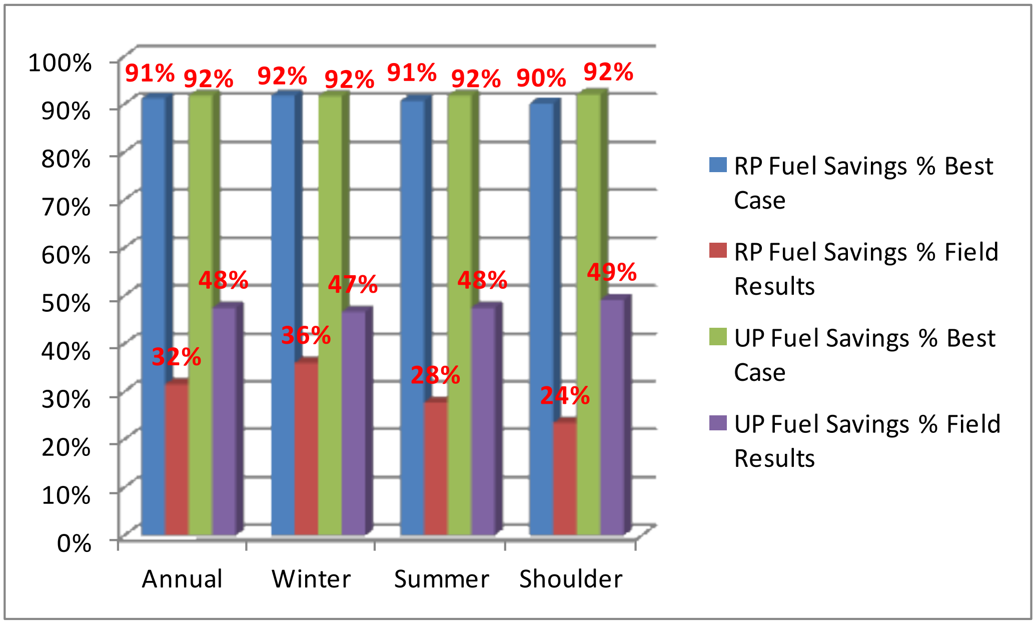

**Figure 3. Police Idling Fuel Savings with HIRS**
**(same for 25%, 50%, 75% vehicle utilization rate)**

The potential gasoline and emission savings are summarized in **Table 5**. As mentioned earlier in this paper, the field results scenario was based on higher idling values than we expected resulting from driver behaviour, HIRS fine tuning opportunities possible when the technology is commercialized and data inconsistencies. However, if the HIRS is refined and driver buy-in is improved, idling reductions could be substantial. These results reinforce the benefit of implementing the HIRS.

Analyzing the fuel consumption from the main engine of the EMS vehicle and from the APU showed that the APU implementation can potentially save up to 3861 L of diesel per year per vehicle depending on the vehicle utilization factors. Also the amount of GHG savings in terms of $CO_2$ emissions is substantial as well. The potential savings could be as high as 10,156 kg $CO_2$/year. **Figure 4** illustrates the percent fuel and GHG savings from the implementation of the APU. The percentages are slightly lower than from the RP and UP technologies because the APU unit consumes fuel as well, although it is much lower than the main engine. Also, at the time this report was written there was no field data available in terms of fuel consumption by the APU.

**Table 5. Annual Fuel and GHGs Potential Savings for UP and RP Vehicles**

| | | Urban Police (UP) | | | | |
|---|---|---|---|---|---|---|
| | | Best Case | | | Field Results | |
| Season | Vehicle Utilization rate | Fuel Savings with HIRS [L/yr] | GHGs Savings [kg $CO_2$/yr] | | Fuel Savings with HIRS [L/yr] | GHGs Savings [kg $CO_2$/yr] |
| Annual | 25% | 3,112 | 7,468 | | 1,611 | 3,867 |
| | 50% | 6,223 | 14,936 | | 3,223 | 7,735 |
| | 75% | 9,335 | 22,404 | | 4,834 | 11,602 |
| Winter | 25% | 835 | 2,003 | | 425 | 1,020 |
| | 50% | 1,669 | 4,006 | | 850 | 2,039 |
| | 75% | 2,504 | 6,009 | | 1,275 | 3,059 |
| Summer | 25% | 783 | 1,880 | | 406 | 973 |
| | 50% | 1,566 | 3,759 | | 811 | 1,947 |
| | 75% | 2,350 | 5,639 | | 1,217 | 2,920 |
| Shoulder | 25% | 1,303 | 7,468 | | 696 | 1,671 |
| | 50% | 2,606 | 6,254 | | 1,393 | 3,343 |
| | 75% | 3,909 | 9,381 | | 2,089 | 5,014 |
| | | Rural Police (RP) | | | | |
| | | Best Case | | | Field Results | |
| Season | Vehicle Utilization rate | Fuel Savings with HIRS [L/yr] | GHGs Savings [kg $CO_2$/yr] | | Fuel Savings with HIRS [L/yr] | GHGs Savings [kg $CO_2$/yr] |
| Annual | 25% | 2,855 | 6,852 | | 988 | 2,372 |
| | 50% | 5,710 | 13,703 | | 1,976 | 4,743 |
| | 75% | 8,564 | 20,555 | | 2,965 | 7,115 |
| Winter | 25% | 902 | 2,165 | | 354 | 851 |
| | 50% | 1,804 | 4,330 | | 709 | 1,701 |
| | 75% | 2,706 | 6,496 | | 1,063 | 2,552 |
| Summer | 25% | 615 | 1,476 | | 188 | 452 |
| | 50% | 1,230 | 2,953 | | 377 | 904 |
| | 75% | 1,846 | 4,429 | | 565 | 1,356 |
| Shoulder | 25% | 932 | 2,236 | | 243 | 583 |
| | 50% | 1,863 | 4,471 | | 486 | 1,166 |
| | 75% | 2,795 | 6,707 | | 729 | 1,750 |

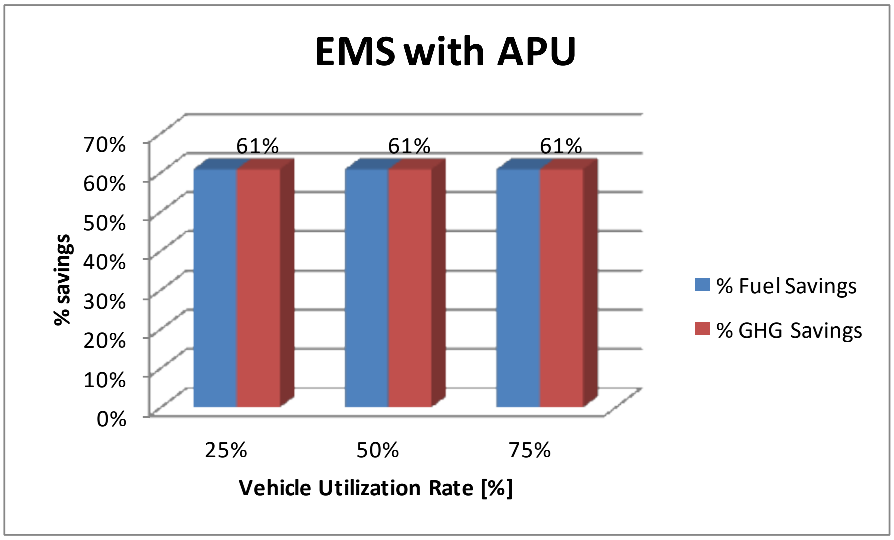

**Figure 4. Annual Fuel and GHG Percent Savings from the APU**

If the values presented in above tables and figures are scaled up to represent the Ontario Fleet, the amount of fuel and GHG savings is substantial. Based on the results to date, the Hybrid Idling Reduction System (HIRS) could be a significant technology for reducing the financial and environmental burdens imposed by fleet idling.

## 3.2 Driver Feedback

Police driver feedback on the performance of HIRS was obtained directly by riding with RP officers, a survey completed by RP officers and from Urban Police mechanics. EMS driver feedback was not available.

### *3.2.1. Positive Feedback*

1. HIRS is effective in reducing idling. Officers felt there was a noticeable reduction in idling and fuel consumption but recommendations for improvement as identified below need to be addressed before HIRS would be viable for use in police vehicles.
2. The system performed reliably and maintained engine battery charge.
3. HIRS is easy to use. The officers like the engine stop light on the dash so they know when HIRS is turned on.
4. UP officers are overall positive about HIRS. The only weakness they mentioned was that when the vehicle engine is turned off, they lose laptop connectivity with their wireless network.

### *3.2.2. Concerns and Recommendations for Improvement*

Officers are not accustomed to starting the car engine for radar work to catch speeders. In some situations, they felt the time needed to start the car engine allows the speeder to travel further and therefore increases the distance they need to pursue the speeder. Occasionally, they forgot to start the car engine before trying to put the transmission into drive; in some cases, the officers believed the speeder would escape. RP officers admitted that they may turn off HIRS for radar work but did mention that if all of the police vehicles were equipped with HIRS, they would become accustomed to having to start the engine to catch a speeder.

There were comments about increasing the pre-set cab temperature for officers. One officer thought that increasing the cab temperature would help keep the windows clear of snow more easily. Another officer said she was always cold and would restart the car every time HIRS turned it off. The commercialized version of HIRS may need to give the driver the ability to adjust cab temperature settings to personal preference.

Officers would like to know the status of HIRS. HIRS operation can catch the driver by surprise and turn off the engine at inopportune times. For example, the system may turn off the vehicle engine just as a police officer needs to accelerate the car from a parked position to merge into traffic to catch a speeder. A dash mounted display screen with a countdown timer to engine shutoff was suggested.

For best performance, HIRS should be plugged into a power source to recharge the auxiliary batteries a few hours every day. UP did plug their vehicle in more often than the RP and this resulted in lower idling for their car.

### 3.3 Implications

For fleet operators who embrace assistive technologies, there is tremendous potential to reduce the impacts from fleet idling. Research on the police HIRS measured the effectiveness of the auxiliary A/C and auxiliary heater in winter, summer and shoulder seasons. Idling was reduced 32-48% for the RP and UP HIRS cars respectively. Although this idling reduction is significant, it should be noted that HIRS was a prototype version for field-testing. A commercial version of HIRS would be optimized and integrated with the vehicle to ideally lower idling even more. Driver feedback identified interface refinements to the system that if addressed would improve acceptance of the technology and further improve performance. If the best-case scenario idling reduction is achieved, the benefits are significantly improved and could be as high as 91% reduction in idling and a 91% reduction in emissions.

Research on the EMS HIRS measured the effectiveness on an annual basis. Unlike the police solution, the impact of weather was not assessed since APU performance does not vary with ambient temperature to any significant extent. EMS HIRS will lower idling fuel consumption by 61%.

The immediate end users that will directly benefit from the outcomes of this research are police, EMS departments, and other fleet operators. Canadian based fleet vehicle auto suppliers will be involved with the development and production of this new generation of fleet vehicles which could open a new market for their operations. Some of the reasons for quantifying and assessing the new vehicle and technology combination are to:

- Make green-conscious selection of proposed new technologies that will reduce air emissions.
- Reveal where environmental and economic benefits can be maximized.

- Achieve environmental and economic goals without compromising emergency response services.
- Establish policy that will be adopted throughout Canada and North America.
- Provide a roadmap for future applications in other fleets (e.g., taxi services).

Research findings will provide essential information for Ontario fleet operators and automotive industry stakeholders in terms of selecting the vehicle technologies that will reduce environmental impacts from fleet operations. In particular, this research helps establish the rationale for assistive technologies and the significant role they can play. Finally, the research allows policy and decision makers to make more accurate decisions on the operations of fleet vehicles as Ontario attempts to reduce its environmental impacts while enhancing its socio-economic status. The benefit to Ontario (and Canada) will be significant by: a) reducing cost, pollution and dependence on non-renewable resources; and b) creating new, potential markets that will benefit Ontario automotive and supplier industries by developing, manufacturing, and/or distributing these new technologies.

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