

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. Elevated 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 Ontario (FCO)** 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, fleet vehicles, hybrid vehicles, idling, fuel consumption, green technologies

CITATION: Prendi, L., King, A., and Tam, E., "Fleet Vehicle Idling - Are Supplemental Hybrid Idling Reduction Systems the Answer?," *SAE Int. J. Mater. Manf.* 7(1):2014, doi:10.4271/2013-01-9095.

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 and wealth of developing countries, 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 by many researchers 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 CO₂ 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 HRS