Attachment 'A'

November 29 2019

Mr. Jason Evans
Fleet Operations Manager
The City of Nanaimo
2020 Labieux Rd
Nanaimo, BC V9T 6J9

Hello Jason,

Thank you for selecting E3 Fleet Review™ as a tool for improving your fleet's 'green' performance. We appreciate the opportunity to assist you in managing the City of Nanaimo's fleet in an eco-friendly manner.

Overall, our 2018-19 E3 Fleet Review shows a positive trend for your fleet. Fleet GHG intensity has decreased in each of the last four reviews, with the greatest reduction taking place in 2018-19.

E3 is about continuous improvement, and with your fleet's history of successful GHG intensity reduction, we encourage you to consider pursuing your E3 Fleet Green Rating soon, to formally recognize your efforts. I have included a guide to Fleet Rating for your perusal.

Our goal at E3 Fleet is to assist you in achieving further improvements. The attached package includes:

- Key Performance Indicator report that summarizes key operating parameters of your fleet
- Key Recommendations for further action to improve your fleet operations
- Detailed E3 Fleet Review reports
- E3 Fleet Rating Guidelines
- EV Cost/Benefit Tool

Sincerely,

Roger Smith
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The E3 Fleet Rating System
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Key Performance Indicators

E3 Fleet has analyzed 2018 operational data provided for the City of Nanaimo fleet and from your E3 reports, selected 21 indicators that provide a snapshot summary of operating parameters. These Key Performance Indicators (KPIs) reflect operating costs, emissions, service levels and in general, client satisfaction with your fleet. Making improvements to each of these will assist in stabilizing operating and capital budgets and reducing cost "spikes" from year to year.

Note: GHG Intensity is displayed in **green** font for your review.

	Key Performance Indicator (KPI) Note: all values calculated based on fleet input data for review period	2009	2010	2011	2012	2013	2018	Measure
1	Fleet units reviewed	121	119	139	133	124	144[1]	Vehicles
	Equipment units reviewed				9	8	7	Equip.
2	NPV	n/a	$2,582,600	$3,657,535	$4,296,998	$4,221,854	$6,792,162	$
3	Cost of capital	n/a	$103,304	$146,301	$171,880	$168,874	$135,843	$
4	Fleet average age	8.9	10.1	9.0	8.4	7.3	7.9	Years
5	Total annual distance travelled	1,217,693	1,357,240	1,316,220	1,296,738	1,289,850	1,269,069[1]	KMs
6	Fleet median fuel efficiency	23.5	21.3	20.5	20.1	19.9	23.7	l/100 km
7	Fleet annual fuel usage	477,543	464,401	480,383	470,767	455,990	633,511	Liters/yr.
8	Fleet GHG intensity (tailpipe)	**0.959**	**0.808**	**0.894**	**0.895**	**0.854**	**0.608**[2]	kg/km
9	Annual GHG emissions (tailpipe)	1,167	1,096	1,176	1,161	1,101	1,449	Eq. Tonnes CO_2

[1] Includes vehicles not included in previous reviews and end of lifecycle vehicles (see report for details)
[2] Based on "normalized" fleet dataset as described in the report

	Key Performance Indicator (KPI) Note: all values calculated based on fleet input data for review period	2009	2010	2011	2012	2013	2018	Measure
10	Fleet GHG intensity (lifecycle)	1.328	1.130	1.234	1.230	1.173	1.271	kg/km
11	Annual GHG emissions (lifecycle)	1,617	1,533	1,624	1,595	1,513	2,010	Eq. Tonnes CO_2
12	Corporate average utilization	11,822	12,567	10,446	10,989	11,517	11,294	KMs
13	Corporate average utilization	984	1,210	1,123	1,047	1,205	1,396	Engine Hours
14	Fleet availability	98.2	n/a	n/a	n/a	n/a	n/a	%
15	Fleet average downtime	4.7	n/a	n/a	n/a	n/a	n/a	Days
16	Annual downtime cost	$515,332	n/a	n/a	n/a	n/a	n/a	$
17	Annual fuel cost	$398,329	$431,154	$516,298	$ 529,067	$ 505,582	$584,534	$
18	Annual repair cost	$587,620	$451,475	$561,153	$ 645,790	$ 582,435	$755,407	$
19	Annual PM cost (if data was provided)	$94,823	$105,952	$ 98,824	$ 89,392	$ 98,841	$137,723	$
20	Projected Current Annual Operating Cost (R&M, Fuel, Capital and Downtime)	$2,014,383	$1,091,885	$1,322,576	$1,436,129	$1,355,733	$1,613,507	$/yr.
21	Maintenance Ratio	0.16	0.23	0.18	0.14	0.17	0.18	PM: Reactive

The City of Nanaimo E3 Fleet Review for 2018-19

Key Recommendations for Action

The following recommendations for further action are based on the E3 team's review and assessment of data supplied, and current Key Performance Indicators (KPI's). Implementing these recommendations will result in a more cost effective, more fuel efficient and lower emission fleet.

Recommended Actions - Fuel Efficiency

Median Fuel Efficiency

For your 2018-19 E3 Fleet Review, input data included kilometers-driven and fuel-used by Sanitation vehicles – data points which were not part of previous reviews. Also included in the dataset were a number of vehicles slated for retirement, for which new, replacement units had been put into service. For this expanded dataset, we calculated your **Median Fuel Efficiency for 2018-19 to be 23.7-l/100 km**.

We feel that Median Fuel Efficiency is one of the most important KPIs for cost and emissions conscious fleet managers to monitor, and take actions to improve upon, on an ongoing basis. This is because Median Fuel Efficiency is directly reflective of your fleet's footprint – it is a measure that encompasses many facets of fleet operations from driver behaviours (i.e., unnecessary idling, harsh driving, unnecessary trips) through to right-sizing of vehicles for their assigned tasks (i.e., getting the job done with smaller, more fuel-efficient vehicles) and the fleet's average age (since older vehicles generally burn more fuel and produce more emissions).

Median Fuel Efficiency indicates your fleet's overall performance and therefore it is a critical success factor to watch closely. Your past E3 Fleet Reviews have shown continuous improvements to your median fuel efficiency from 2009 to 2013. This indicates that your fleet is on a healthy trend, and the strategies you have undertaken to improve your fleet performance are working.

Median Fuel Efficiency is easy to calculate using just two data points (fuel use & kilometers-travelled). Monthly reporting, including current Median Fuel Efficiency and progress toward target, would be best but quarterly reporting would suffice.

E3 recommendations: Our recommended actions are to (1) regularly monitor fleet median fuel efficiency and (2) set a target for ongoing improvement.

Data 'Normalization' for the City of Nanaimo's 2018 E3 Fleet Review

In our 2018-19 Fleet Review, Nanaimo's fleet size increased by 20 units when compared to the last review in 2013. While average utilization remained at approximately the same level, total kilometres-travelled increased by almost 300,000. Because data for heavy-duty trucks was included in the 2018 fleet review group - these vehicles being high-mileage and heavy fuel consumers - average fuel consumption, measured in litres per 100 km, for the expanded fleet was negatively affected. Data for these units was not part of the last review in 2013 because their performance was then tracked by engine hours, not by kilometres as in the rest of the fleet.

For the purposes of making 'apples to apple' comparisons with fleet reviews from previous years, we 'normalized' the 2018 fleet review data by excluding the Sanitation heavy-duty trucks. We also eliminated data for a number of decommissioned vehicles slated for retirement, since partial-year data for their replacements was included and auto-extrapolated by E3 Fleet Review to depict one-year of operation, which in-effect, double-counted the data.

After the normalization process was completed, a reduction in GHG tailpipe emission 'intensity' (CO_2e kg/km) was evident for the active fleet relative to previous years.

Options for Improved Fuel Efficiency

The following section provides some technology and operational options for improving on your median fuel efficiency.

Diesel-Powered Vehicles

We note that you currently have a number of diesel-powered pickups and vans as well as medium to heavy-duty trucks in your fleet. For the light-duty units (pickups and van), as you are aware, the upfront capital cost can be substantially more for the diesel engine option, but they are up to 20% (or more) fuel-efficient than gasoline-powered vehicles.

Today's diesels produce radically reduced smog-causing emissions than earlier models. The added bonus is powering your diesels with renewable, clean biodiesel as you are now doing. On the downside, standard fossil diesel produces about 22% more greenhouse gas emissions than standard fossil gasoline. So, even though diesels may reduce your fuel usage by 20% or more, they may produce the same level, or more GHG emissions. Because you have opted for B5 biodiesel in your fleet, this reduces the overall GHG impact.

Based on fuel usage and cost reduction a positive business case can often be made for the additional price for diesel engines. Diesel pickups are available and diesel cars are also offered from some auto OEMs, with fuel consumption comparable to hybrids.

E3 recommendation: From an emissions reduction perspective, our recommendation is to carefully assess the cost/benefit and GHG emissions advantages of light and medium-duty diesels case by case before investing in the diesel option.

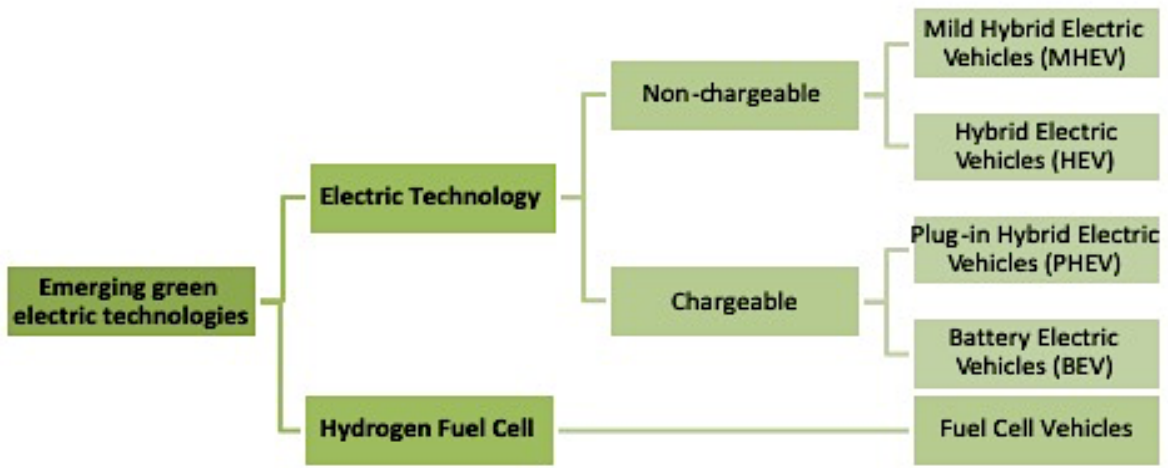
Hybrids, Plug-in Hybrids and Battery-Electric Vehicles

We note that you have deployed four EVs in your fleet. New models of original equipment manufacturer (OEM) hybrids, plug-in hybrids (PHEV) and battery-electric vehicles (BEVs) appear each model year as their popularity increases.

While pickups and medium to heavy-duty truck EVs are not yet commercially available almost every manufacturer has announced plans for EV options. While the upfront costs may be higher, electric vehicles (EVs) are a solution to rising fuel costs and emissions.

Please see *Figure 1 - Electric Vehicle Technologies* (overleaf) which displays EV options.

Figure 1 – Electric Vehicle Technologies



An expanded number of electric vehicle options are regularly emerging which may be excellent choices for Nanaimo. Cars and SUVs are now available, while pickups and medium to heavy-duty trucks will soon be available. It is conceivable that in our lifetimes, the entire fleet could be powered by zero-emission electric vehicles. Globally, some jurisdictions have already legislated the end of the internal combustion engine by 2050, paving the way forward for electric vehicles.

EVs are not necessarily a "silver-bullet" solution, as their additional capital cost must be offset by fuel cost savings in order to be cost-effective. Savvy fleet managers will seek applications within their fleets where the level and type of usage the vehicles will be subject to, will deliver sufficient fuel cost savings to offset their additional cost of capital and after the vehicles are fully depreciated (usually ~5 years), deliver net cost savings until the end of their economic life-cycle (often ~10 years).

Planning for an Electric Vehicle Future…

The average annual kilometers-driven by your fleet is relatively low (typical for all municipal fleets) and so your vehicles daily range requirements are well within the range of today's EVs (for example, the 2020 Chevrolet Bolt has a range of 417 kms on a full charge).

Your vehicles return to base each night, making them ideal for overnight re-charging. Therefore, it is conceivable that, if one day in the future, electric and plug-in hybrid vehicles replaced all current units, they could be driven almost entirely on electric power. The potential fuel savings would be almost $600k annually (based on your fuel spend in 2018). Of course, this is a very idealistic situation and there would be associated costs such as electricity for re-charging the vehicles, but we present this information to encourage your interest in vehicle electrification.

EV Cost Benefit Tool

E3 recently developed a new EV/ICE Cost-Benefit Calculator that helps fleet managers determine the potential savings and emissions reduction for EVs when compared to traditional fossil-fuel vehicles. A copy of this tool is included with your E3 reports package.

E3 recommendation: Consider adding more hybrid, plug-in hybrids and battery-electric vehicles to your fleet and ongoing investment in EV charging systems.

Exception Units – High Fuel Consumption

E3 Fleet Review has identified 30 units in your fleet with higher than average fuel consumption for similar vehicles within your fleet. These 30 vehicles burned fuel at a rate at least 50% higher than your fleet average.

Your E3 Sorted Fleet Detail Sheet shows how all units are performing and those that are performing worse than similar vehicles in your fleet. Pinpoint the problem units, find the root cause(s) and take action(s). Consider improvements that could be made ranging from eco-driver training through to technological improvements (such as idling stop/start devices, auxiliary battery systems etc.).

There are several potential causal factors for lower than optimal fuel-efficiency. These may include:

- Vehicle mix and right sizing (are the right sized vehicles being used for the vocational needs?)
- Driver behaviors (are drivers idling vehicles excessively or wasting fuel in other ways?)
- Weather (was the past winter more severe in your area?)
- Mechanical issues (the fleet has aged – are there mechanical issues that should be addressed?)

E3 recommendations: Systematic reviews of all exception units in your fleet that are driving up your fuel bill (and emissions) and remedial actions, case-by-case.

Right-Sizing Vehicles

Some fleet managers used to subscribe to the old adage *"identity the size of truck you really need for the job — and then buy one bigger*". This anachronistic thinking led to fleets with oversized vehicles, poor fuel economy and high emissions. Today, savvy fleet managers know that old approach is wrong. The correct approach is to right-size the fleet vehicles – that is, correctly specify the right sized vehicles for the job at hand, which will lead to optimal fuel efficiency and lower overall operating cost.

Low Emissions Vehicles

Prepare vehicle specifications for competitive bids (RFPs, tenders) to include a weighting for vehicles being offered with the highest fuel-efficiency. The past predicts the future and your E3 "*Sorted Fleet Detail Sheet*" will show you which of your vehicles have been performing best (and worst) when compared to similar vehicles within your fleet. Using this information, on a go-forward basis, purchase the best performing vehicle models when replacing vehicles in the same class.

E3 recommendation: Purchase high efficiency/low emissions vehicles that meet operational needs e.g. hybrids, plug-in hybrids, battery-electric vehicles, compact cars, etc.

Green Technologies

Green vehicle technologies such as idle shutdown devices, battery backup systems for DC loads and auxiliary cab heaters will deliver fuel-efficiency increases.

E3 recommendation: Invest in green vehicle technologies which have been tested, proven and verified to reduce fuel consumption.

Driver Behaviours – Excess Idling

Most drivers wish to "do the right thing" and simply suggesting that excessive idling is not acceptable is often enough but for some, old habits are hard to break. All drivers would benefit from driver eco-training around the negative effects (i.e., fuel costs, emissions, health impacts) of engine idling. Fuel-efficient driver training can come in many forms, from hiring a training contractor, to setting up an in-house trainer, and even offering online training.

For more information about free of charge "Fleet Smart SmartDriver" fuel efficient driver training programs offered by Natural Resource Canada, go to: http://fleetsmart.nrcan.gc.ca/index.cfm?fuseaction=fleetsmart.smartdriver. You may also want to take advantage of an online 25 minute tutorial provided by NRCan and Stantec, which is currently available for free: www.ecodrivingonline.ca

E3 recommendations: (1) Ongoing vigilance with regard to excessive engine idling and (2) fuel-efficient, eco-driver training.

Recommended Actions - GHG Emissions

Biodiesel and Renewable Diesel

E3 supports your use of B5 biodiesel and we recommend that you continue to use renewable, low carbon fuels that are available and wherever operationally practical.

Biodiesel can be used in higher blends safely and without issues. Biodiesel in higher blends than B5 will reduce your emissions further and contribute positively to our economy with minimal risk and additional cost. We caution that it may be challenging to find a local supplier of higher-blend biodiesel.

Biodiesel is a renewable fuel made from virgin feedstocks and used vegetable oils. Animal fats such as beef tallow and fish oil can also be used to make biodiesel fuel. Biodiesel can be blended in a variety of ratios with conventional fossil diesel to obtain different blends such as B2 (2% biodiesel), B20 (20% biodiesel) or it can be used in higher blends (more than 20% biodiesel) and "neat" which means up to 100% biodiesel (B100).[3]

[3] EPA - https://www3.epa.gov/region9/waste/biodiesel/questions.html

According to the Renewable Fuel Regulation, as of July 1st, 2011 2% of the diesel and heating oil sold in Canada must be renewable. The Greenhouse Gas Reduction (Renewable & Low Carbon Fuel Requirements) Act and the Renewable & Low Carbon Fuel Requirements Regulation were introduced to:

- Reduce British Columbia's reliance on non-renewable fuels
- Help reduce the environmental impact of transportation fuels
- Contribute to a new low-carbon economy

Between 2010 and 2017, the release of over 7.73 million tonnes of greenhouse gas emissions was avoided under the Regulation. These significant reductions were achieved without limiting the various ways in which British Columbians use their vehicles.

Part two of the Act[4] establishes renewable fuel content requirements for gasoline and diesel sold in British Columbia:

- Fuel suppliers must ensure that they have a minimum renewable fuel content of five percent (5%) for gasoline and four percent (4%) for diesel, on a provincial annual average basis
- Fuel suppliers have the flexibility to vary their blend percentages and can choose where in the province they supply renewable fuel blends, as long as they meet the provincial annual average requirement for renewable fuel content

Part 3 of the Act establishes low carbon fuel requirements for fuels sold in British Columbia:

- Fuel suppliers must progressively decrease the average carbon intensity of their fuels to achieve a 10% reduction in 2020 relative to 2010

Under the Regulation[5], fuel suppliers choose their own approach for compliance with Part 3 requirements. Fuel suppliers may choose to:

- Supply more low carbon fuels
- Acquire credits through a Part 3 Agreement
- Trade credits with other suppliers

Despite having a higher energy content than conventional diesel, fuel economy is reported to be slightly lower with biodiesel: using 100% biodiesel (B100) results in a 10% lower fuel economy, B20 in a 2% lower mileage.

[4] https://www2.gov.bc.ca/gov/content/industry/electricity-alternative-energy/transportation-energies/renewable-low-carbon-fuels

[5] Full details of the Renewable and Low Carbon Fuel Requirements Act, Renewable And Low Carbon Fuel Requirements Regulation, are available for viewing or download: http://www.bclaws.ca/civix/document/id/complete/statreg/394_2008/search/CIVIX_DOCUMENT_ROOT_STEM:(Renewable%20and%20Low%20Carbon%20Fuel%20Requirements%20Regulation)%20AND%20CIVIX_DOCUMENT_ANCESTORS:statreg?3

The same range of oils and fats that can be used for biodiesel can be fed into a modified hydro-treating unit in a conventional diesel refinery to produce a fuel with very similar properties to diesel, which has been called "hydrogenation-derived renewable diesel" or simply "renewable diesel.

Hydrogenation-derived renewable diesel (HDRD is the product of fats or vegetable oils—alone or blended with petroleum—refined by a hydro treating process. Hydrogenation-Derived Renewable Diesel (HDRD), also known as green diesel or second-generation biodiesel, is produced by refining fats or vegetable oils in a process also known as Fatty Acids to Hydrocarbon Hydro treatment.

Renewable diesel and biodiesel use similar feedstocks but have different processing methods and create chemically different products. HDRD has an identical chemical structure with petroleum-based diesel and is free of ester compounds.

Renewable diesel produced from waste animal fats from rendering has low carbon intensity and is also referred to as "advanced" renewable diesel. In the future, even algae and bacteria could be used as a feedstock.
Renewable diesel (HDRD) is claimed to have advantages over biodiesel:

- It has a better emission profile – reduced particulate, hydrocarbons, and carbon dioxide emissions as well as lower sulfur content.
- HDRD production does not produce glycerin as a co-product.
- HDRD has a lower production cost because it uses existing hydro-treatment process equipment in a petroleum refinery.
- Renewable diesel has a better low-temperature operability than biodiesel, thus it can be used in colder climates without gelling or clogging of fuel filters.

Renewable diesel[6] (also known as Hydro treated Vegetable Oil or HVO) and traditional biodiesel (also known as Fatty Acid Methyl Ester or FAME) are often confused. They are, however, distinctly different products, even though both are made from organic biomasses. The differences can be found, for example, in their production process, cleanliness, and quality.

Premium-quality, HVO-type renewable diesel is made primarily from waste and residues. In the production process, impurities are removed from the raw materials that are then hydro treated at a high temperature. The outcome is a colorless and odorless fuel of an even quality that has an identical chemical composition to fossil diesel. It is also often called an "advanced biofuel" or "second-generation biofuel".

Traditional, first-generation FAME-type biodiesel, on the other hand, is produced by esterifying vegetable oils or fats. The esterification process restricts the use of poor quality or impure raw materials, such as waste and residues. The quality of traditional biodiesel also varies in other respects based on the raw materials used.

Even though both bio-based fuels help replace fossil fuels with renewables and thereby reduce global climate emissions, only renewable diesel can be used in high concentrations and as a standalone product in all diesel

[6] https://www.neste.com/what-difference-between-renewable-diesel-and-traditional-biodiesel-if-any

engines. The use of renewable diesel in high concentrations recently became even easier in Europe because of a new EN 15940 standard. The U.S has already been using this product in high concentrations because their diesel fuel quality requirements differ from those in Europe. Fuel quality requirements for modern automotive technology and advanced engines are considerably higher. Blended biodiesel is available from a limited number of suppliers in British Columbia and the fuel may be priced competitively[7] with fossil diesel.

Biodiesel Gelling

Biodiesel is essentially oil therefore it solidifies in cold temperatures (commonly referred to as *gelling*). If the fuel begins to gel, it can clog engine filters and eventually thicken enough to prevent flow from the fuel tank to the engine. The temperature at which crystals begin to form is called *cloud point*. The cloud point varies considerably from one biodiesel source to another. Due to winter climate conditions, the cold flow properties of biodiesel are an important consideration. *It must be noted that even petroleum diesel can gel, thus additives are often used during wintertime as a preventative. In the case of biodiesel blends, such additives can aid in reducing the cloud point during winter months.*

E3 recommendation: Consider the use of higher blends of biodiesel (B20 seasonally adjusted).

Biodiesel at a Glance

Strengths	Weaknesses
1. Safe and non-toxic 2. Proven, mature technology in North America and Europe 3. No conversion costs to vehicles 4. Minor costs to convert fuelling infrastructure (tanks and pumps) 5. Larger blends (B5 to B100) result in greater emissions reduction 6. Warranty approved by most engine manufacturers[8] 7. Biodiesel increases lubricity and therefore it is known to extend engine life (note: today's ultra-low sulfur diesel suffers from reduced lubricity – biodiesel is commonly used to counteract this issue) 8. The GHG reduction potential depends on the source of biodiesel	1. Although biodiesel production is abundant, there are a limited number of vendors and distributors 2. It may be necessary to purchase higher blends directly from wholesalers 3. There are viscosity issues related to the higher-blends (B5 or higher) in cold weather conditions that require special attention 4. Possible perception by persons that 'food' production is sacrificed for fuel production 5. Potential of higher fuel cost (depending on market conditions) Note: at this time B20-B50 is approximately the same price or less than fossil diesel 6. Biodiesel has between 2% and 8% lower energy content than regular diesel[9]

[7] Dependent on market and other conditions at the time of implementation

[8] Sources: www.neste.com is a producer of renewable diesel. The company describes itself as the global leader in the renewable diesel market and wants to develop significant business from non-traffic renewable product markets by the end of the decade. http://biodiesel.org/using-biodiesel/oem-information ,

[9] https://www.driveclean.ca.gov/Search_and_Explore/Technologies_and_Fuel_Types/Biodiesel.php

Fuel Ethanol

All gasoline in BC contains a percentage of ethanol. Ethanol is obtained from the fermentation of sugar or converted starch contained in grains and other agricultural or agro-forest feedstock.

Ethanol is presently made principally from corn and wheat. Technologies are being developed to produce ethanol from grasses, wood and algae amongst others. Ethanol fuel is distilled and dehydrated to create a high-octane, water-free alcohol.

The exact emissions reduction potential varies based on the biomass used. E.g. low-blend ethanol from corn produces about 3 to 4 percent fewer greenhouse gas emissions than gasoline. Low-blend (e.g. E10) made from wood or agricultural cellulosic materials would produce 6 to 8 percent fewer emissions compared with gasoline.

Ethanol[26] is a renewable fuel because it is produced from biomass. Ethanol also burns more cleanly and completely than gasoline or diesel fuel.

Ethanol reduces greenhouse gas (GHG) emissions because the grain or other biomass used to make the ethanol absorbs carbon dioxide as it grows. Although the conversion of the biomass to ethanol and the burning of the ethanol produce emissions, the net effect can be a large reduction in GHG emissions compared with fossil fuels such as gasoline.

Some vehicles (i.e. flex-fuel, E85 capable vehicles) are specially manufactured to operate on an ethanol blend that contains up to 85 percent ethanol and at least 15 percent gasoline (E85). The 15 percent gasoline is needed to assist in engine starting because pure ethanol is difficult to ignite in cold weather.[10]

There are an estimated 17,000,000 flex-fuel, E85 capable vehicles in America and more than 600,000 in Canada. In the U.S, E85 is widely available, however in Canada it is scarce. Many vehicles in Nanaimo's fleet are flex-fuel capable and can use higher blends of ethanol than already in standard gasoline.

E3 recommendation: For further GHG reductions, consider higher blends of ethanol (up to E10 and up to E85 for your flex-fuel enabled vehicles) if practical and if a supply source is available.

Natural Gas

We note that eight units in the Nanaimo fleet are currently powered by natural gas and we support your use of this low carbon fuel.

Natural gas, a fossil fuel composed of mostly methane, is one of the cleanest burning alternative fuels. It can be used in the form of compressed natural gas (CNG) or liquefied natural gas (LNG) to fuel cars and trucks. Vehicles that use natural gas in either form are called natural gas vehicles (or NGV).
Natural gas is found in abundance in porous rock formations. It is extracted from the ground, processed to remove impurities, and compressed to be stored and transported by pipeline.

NGV can be used as the single fuel for a vehicle, which is referred to as "dedicated CNG" or it can be used in conjunction with another fuel type (usually gasoline or diesel) referred to as "dual-fuel".

CNG at a Glance

Strengths	Weaknesses
1. Lower fuel cost than gasoline or diesel 2. CNG can be used in light, medium and heavy-duty applications 3. A CNG-powered vehicle gets approximately the same fuel economy as a conventional gasoline vehicle on a diesel-gallon-equivalent basis 4. Reduced GHG emissions by more than 10%, particularly in dedicated CNG units 5. Lower CACs compared to other fuels 6. Low safety risk 7. No range issues for dedicated CNG units 8. Piping directly to fuelling sites reduces upstream emissions resulting from delivery	1. Vehicle conversion costs are significant (payback typically in 3-10 years depending on the application and usage) 2. In-house CNG fuelling systems carry significant capital costs, (although subsidies may be available) 3. Additional electricity costs for CNG refuelers 4. Potentially increased fueling time: if slow refuelers are employed, fuelling will take overnight; with fast refuelers, fuelling will take approximately the same time as traditional vehicles

CNG offers many advantages for fleets and although there are upfront capital costs, savings will likely ensue (a thorough business case should be prepared before making the switch to CNG).

A mix of slow (overnight) refuelers that would employ off-peak electricity to power the CNG compressors to refuel the majority of the fleet vehicles, combined with a small number of fast-refuelers would likely be the optimal arrangement; the ultimate arrangement employed by Nanaimo should be determined methodically based on the number and type of vehicles projected to be powered by natural gas.

E3 recommendation: Consider expanding the use of natural gas in the Nanaimo fleet, possibly in light-duty units such as pickup trucks.

Renewable Natural Gas

Renewable Natural Gas, or biomethane, is a fully renewable energy source. RNG is made from biogas - a gaseous product of the decomposition of organic matter —anything from crop residues and animal manures to municipal organic wastes and food processing by-products.

RNG is essentially biogas that has been processed to purity standards and is thus a pipeline-quality gas that is fully interchangeable with conventional natural gas. Like conventional natural gas, RNG can be used as a transportation fuel in the form of CNG or liquefied natural gas (LNG).

RNG production has become an important priority thanks to its environmental benefits. RNG production is usually based on capturing and purifying the gas from collected organic waste.

RNG at a Glance

Strengths	Weaknesses
1. Interchangeable with fossil natural gas 2. Can be used to power natural gas vehicles without further conversion 3. Very low GHG emissions 4. RNG can be produced year-round without intermittency	1. The costs for an anaerobic digester are considerable and depend on the required size and capacity

Production of Biogas

In general, the feedstocks for biogas systems can be grouped into five broad categories, based on the primary source of the organic material:

- Agricultural organics
- Residential source separated organics (SSO)
- Commercial SSOs
- Landfill gas (LFG)
- Wastewater treatment residuals

Anaerobic digestion is a process during which the waste (from landfills or waste water treatment plants) is converted into methane and carbon dioxide in a digester or holding tank. The gas produced is then cleaned or purified to meet utility pipeline specifications. The digesters can be located at waste water treatment plants, landfills, or at green bin waste facilities.

RNG Emissions Reduction Potential

The use of RNG is a natural progression from the use of fossil-based CNG. While use of natural gas as fuel requires large infrastructure investments, RNG has a very high emissions reduction potential of ~79%. RNG is thus an

important fuel to consider for use in medium and heavy-duty vehicles. Nevertheless, the technology of producing RNG is still under development and it is expected to become more widespread in the near future.

When RNG is used to fuel natural gas fleet vehicles, lifecycle greenhouse gas emission reductions are significant. Different sources estimate the lifecycle reduction to be between 75% and 90% as compared to diesel.

E3 recommendation: Consider organically derived (renewable natural gas or "RNG"). RNG can be produced from landfill waste organics (see: http://vikingstrategies.ca)

Recommended Actions – Utilization

Overall your utilization rate is 11,294 km/yr. We acknowledge that utilization measured by kilometers-driven is not necessarily a good measure of vehicle productivity for the City of Nanaimo fleet. However, in the absence of more relevant measures, it is worthwhile monitoring as an indicator of fleet productivity.

E3 Fleet Review has identified 27 units within your fleet that have utilization at least 50% less than similar vehicles in your fleet. If vehicles are under-utilized and redundant then they may just be stranded assets and an unnecessary financial drain to your organization.

E3 recommendation: Consider management actions toward reducing the number of low utilization units on an ongoing basis. Reducing then number of low utilization units may free up capital that could be applied to increased fleet modernization. E3 suggests a top-down directive / policy requiring user departments to regularly review their assigned units and reduce their under-utilized vehicles.

Recommended Actions - Preventative Maintenance

High levels of vehicle uptime are a prime indication of success in fleet management. There are only two ways to increase uptime:

1) Decrease the age of the fleet by purchasing new vehicles; or,
2) Increase the level of preventive maintenance (PM) being completed in order to head off reactive repairs (i.e., breakdowns).

We have calculated your Maintenance Ratio to be 0.18, meaning that for every dollar spent on reactive repairs (unplanned repairs, breakdowns), you spent eighteen cents on preventive maintenance (PM). This measure is a prime indicator of vehicle reliability and a way of determining whether your team's work on carrying out preventive maintenance is sufficient (or excessive).

E3 recommendation: Consider tracking maintenance ratio, in the way we have described, on an ongoing basis as a KPI for managing your fleet.

Tracking Downtime

It is especially important to track downtime on a per-vehicle basis in order to measure the effects of your PM efforts relative to fleet aging. This is essential information for fleet managers since it directly reflects the effectiveness of fleet management decisions, in particular vehicle age and preventive maintenance activities.

Once a history of downtime and maintenance ratio for all vehicles in your fleet is available over a period of time, determine what level of downtime is acceptable to maintain good service for your internal clients. Discussions with your fleet user groups would reveal the level of uptime that is essential to them to maintain their workflow.

Compare the downtime and maintenance ratio for each vehicle. Trends will emerge that will show which units are less reliable and you will be in a position to complete causal analysis. In some cases, preventive maintenance may need to be 'ramped up' with more intensive PM inspections and/or a higher frequency[11], however there may be other reasons such as:

- Is the vehicle too old for front line service?
- Is the driver harsh or abusive?
- Is it the correct vehicle for the job?

E3 recommendation: Consider tracking downtime[12] on a per-vehicle basis.

PM Scheduling

Most fleets conduct scheduled preventive maintenance (PM) inspections (i.e., A and B level inspections) together with an oil & filter change on a pre-determined number of days/weeks/months since the last such event. Many fleets include a second parameter of kilometers driven, and a few base their PM's on elapsed engine hours. To use the example of one "best-in-class" fleet operation, the fleet's vehicles were scheduled for their next PM and oil change on the first to occur of: (1) three months, or (2) 5,000 kilometers, or (3) 300 engine hours.

As described, this degree of scheduling precision requires a robust fleet management software system that is capable of complex PM scheduling. With a higher degree of effort, in-house solutions can also be developed using basic spreadsheet software that would be just as effective. Either way, the payback can result in huge savings for a fleet by fine-tuning its PM intervals.

For fleets that schedule their PM inspections and oil changes based on a single parameter (i.e., the time elapsed since the last event only), it is possible that costly engine oil is being drained and disposed of, *that may have many kilometers of serviceable life remaining*.

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[11] E3 has monitored downtime and maintenance ratio for over 150 Canadian fleets. We have concluded that there is no "perfect ratio" of reactive: PM but in almost all situations, a ratio of .50 (i.e., 50 cents spent on PM per $1. reactive) yields the highest levels of uptime and reduces downtime to a minimum.

[12] Downtime is generally considered to be all time that a vehicle is out of service during prime business hours for unscheduled (reactive) repairs.

E3 recommendation: Use multiple parameters for PM scheduling. These parameters would include (1) the time since the last PM (days/weeks/months) and, (2) either kilometers-driven or engine hours operated.

Engine Oil Sampling

By tracking downtime and maintenance ratio as described in the previous section, fleet management can make an assessment as to the frequency with which specific units need to receive routine PM inspections and oil changes. But there is another consideration that can help reduce waste and reduce cost.

Laboratory oil sampling is inexpensive and it will pinpoint exactly when oil and filter replacements should be done in order to reduce engine wear and extend life. Laboratory oil analysis could mean extending the intervals between oil changes, which would obviously save considerable resources and money. Once sampling has been completed, you can compare the laboratory's oil change frequency recommendation to your own planned intervals for PM inspections (based on maintenance ratio and downtime assessment as previously described) and make well-informed decisions on the optimal maintenance intervals for your fleet.

E3 Recommendation: Consider engine oil sample analysis for your vehicles and equipment..

Recommended Actions - Capital Budgeting and Vehicle Replacement

In preparing your E3 Data Input Form, you will recall the section prompting you to input data your "Best in Class" (BIC) choices of replacement vehicles for units in your fleet approaching the end of their planned life cycles. Using your inputs[13], and *based on your current vehicle retention practices* as reported, we have calculated a number of critical cost and environmental impacts to your operation should your replacements plans be realized.

Your capital plan impacts are displayed in the following table. We have determined that your replacement plan would lead to a reduction in fuel usage, fuel cost and GHGs in addition to operating cost reductions.

	City of Nanaimo – Capital Plan Impacts	Capital Plan Impact	Measure
1	Vehicles Due for Replacement (based on current retention cycles)	32	Vehicles
2	Fleet Average Age if all Replacements Made	4.3	Years
3	Capital Budget Required for Replacements	$1,195,425	$
4	Estimated Capital Cost Increase (or lease payments)	$44,202	$
5	Potential Fuel Cost Savings (increase)	$34,721	$/yr.
6	Potential Fuel Usage Reduction (increase)	28,326	Liters
7	Net Cost Reduction (increase) if all Replacements Made	$115,914	$/yr.
8	Potential GHG Reduction (increase)	67.0	Eq. Tonnes CO_2

Aged fleets will almost always have poor reliability and high levels of costly downtime, high repair costs, decreased safety, poor fuel economy and the resultant increased costs of fuel because of old technology vehicles. There are additional benefits of a newer, more fuel-efficient fleet and these include increased vehicle uptime. a lower risk level and quite possibly, improved employee morale.

The outcomes we have calculated (as shown in the above table) are obviously positive. By continuing to invest capital in your fleet, you would reduce fuel usage and emissions. We urge the City of Nanaimo to place emphasis on capital spending priorities and consider renewing/refreshing the fleet each year.

E3 recommendation: Continue to invest capital in renewing your fleet to reap the benefits and head off the negative issues associated with fleet aging.

[13] If you did not provide your own data for this section, BIC default vehicles built into the E3 Fleet Review tool were used to make the calculations.

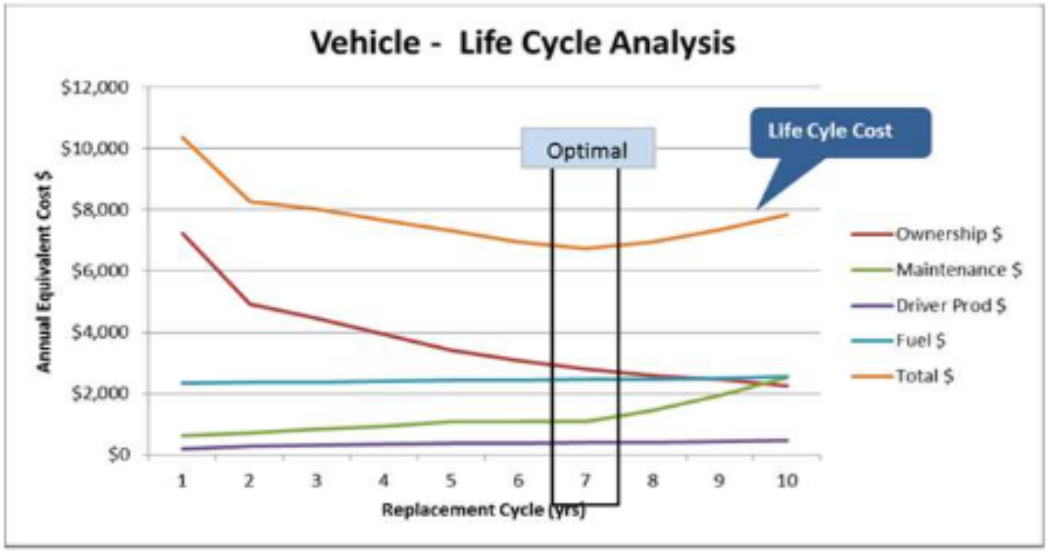
Life Cycle Analysis

There are some older vehicles in your fleet including several pickups from 13-20 years of age. In a business context, older vehicles may be exposing City of Nanaimo to unacceptable risks. Metals and other materials used in vehicles, such as those used in frames other critical components and systems all have a pre-determined resistance to bending moment (RBM) and yield strength.

While todays vehicles are built far better than ever before, materials used to build motor vehicles are designed to last for a prescribed number of duty cycles and if exceeded, components will eventually fatigue and break. Rubber and synthetic materials such as those used in braking systems and elsewhere are also subject to deterioration and will in time fail. For vehicles operated beyond their optimal economic life cycles, the cost of repairs may exceed the cost of capital for their replacement. Also, they may be exposing the owner to risk and liability due to unexpected critical component failures.

One of the E3 member tools you will find on at www.e3fleet.com is a basic Life Cycle Calculator. This tool is used to help determine the economic life cycle of your vehicles. If you do not have a clear and factual, data-based guideline for the optimal replacement cycles for your vehicles based on historical cost data, we strongly recommend having E3 complete economic Life Cycle Analysis (LCA) for all City of Nanaimo vehicle types.

Figure 2 - Example of Life Cycle Analysis



Our E3 analysts specialize in completing LCA for fleets across Canada. Upon your request, our optional, extra cost LCA study/service will help you to prepare long-term capital budget planning that will lead to extracting the most value from each and every vehicle in your fleet.

E3 recommendation: Life Cycle Analysis should be completed and optimal economic replacement cycles for your fleet determined based on analysis of historical cost data.

Capital Budgeting

A guideline for fleet replacement is to invest capital at the rate of depreciation. For example, if your new vehicles are depreciated over five years, then 20% of your current NPV would be required each year to maintain the average age of your fleet at the desirable level. Important *note: This guideline is only valid if performance indicators such as uptime and fuel-efficiency are satisfactory – if not, then a one-time increased spend would help to bring the fleet's average age and performance up to an acceptable level.*

New Vehicle Specifications

When competitively bidding (RFP, RFQ, tender, etc.) for new vehicles and equipment for the fleet, consider asking bidders to state the fuel economy ratings of their offerings. Some E3 members have opted to purchase the most fuel-efficient vehicles offered to them through an RFP — even though they were not the least expensive. In one fleet, the manager decided that the vehicles, which offered higher fuel economy ratings, would yield the lowest total cost of ownership than vehicles that were less expensive to acquire.

- Another consideration when acquiring new fleet vehicles includes a review of the manufacturers handling of waste stream – i.e., what is the percentage of materials used in manufacture of the vehicle than can be recycled? Most manufacturers today place a degree of emphasis on this matter and have the information readily available for the asking.

- When creating specifications for new vehicles investigate whether environmentally friendly and compliant waterborne paint will be used for your vehicles. The federal government has new and more stringent regulations regarding Volatile Organic Compounds (VOC) and its important to know about the OEM's handling of this legislation. The same applies for repainting of in-service vehicles.

Recommended Actions – Fleet Operations

"Data is King"

'If you can't measure it you can't manage it'. This popular mantra is especially relevant to fleet operations. If you do not currently have an effective way of obtaining fleet data from your vehicles consider GPS based telematics. Although their use can be contentious in some corporate environments, they provide a wide range of advantages for fleet managers that include real-time monitoring of vehicle utilization, performance (in terms of fuel economy and GHG emissions), route planning, operator safety and more.

Shop Operations

Whether you maintain your vehicles in-house or outsource this activity, here are some eco-friendly procedures to consider:

- **Aqueous parts cleaners**. Aqueous parts washers are a new generation of water-based small parts cleaning equipment that are safe and biodegradable yet have the cleaning power of traditional cleaning solvents.
- **Filter recycling**: Used oil, fuel, coolant and air filter should be recycled. Local service providers may be available for this task.
- **Waste Oil**: Recycling of used oils and the creation of new products from the recycled oils, includes the recycling of motor oil and hydraulic oil. Oil recycling benefits the environment lessens the likelihood of used oil being dumped on lands and in waterways. Service providers in your area will pick up waste oils for recycling.
- **Vehicle Washing**: Review your vehicle washing processes to ensure that contaminants are not being released into the ground water, rivers, lakes, streams or the ocean. Give preference to cleaning processes that re-use wash water.
- **Tire recapping**: For large trucks, consider recapping your tires. Quality tire casings can be re-capped, extending their life cycle and saving money. Ensure that all end of cycle scrap tires are disposed of in an environmentally friendly way.
- **Synthetic Oils**. Most engines today are compatible with synthetic oils. Synthetic oil is used as a substitute for lubricants refined from petroleum when operating in extremes of temperature, because, in general, it provides superior mechanical and chemical properties to those found in traditional mineral oils. Synthetics typically cost more but may extend oil drain intervals, thereby potentially reducing expense and wasting natural resources.

Thank you for participating in the E3 Fleet Review program. I hope our comments and recommendations are helpful and thought provoking to you.

If you have any questions about your E3 Fleet Review please contact me anytime.

Regards,

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