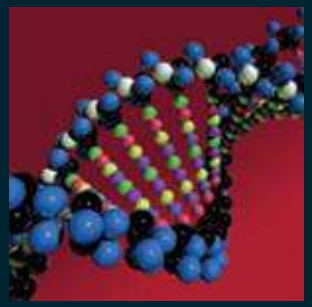
Green Vehicle Evaluation and Selection Tool (GVEST)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Background

- Toronto's Fleet Services Division (FSD) is responsible for purchasing, managing and maintaining the vehicles, providing driver training and managing the fuel.
- FSD also leads implementation of the Green Fleet Plan.
- FSD identified the need for a systematic decision-making tool to help Toronto select the best new, green vehicles and assess the vehicles' performance.
- In answer to this need, the GVEST framework was developed by ENVIRON for the FSD

What is GVEST?

- Excel-based tool that compares different vehicle technologies based on pollutant emissions and lifetime cost
- Purpose: to encourage fleet managers make green purchasing decisions
- Tool estimates pollutant emissions from each technology, based on detailed tailpipe and life cycle emission factors
- The most current version of GVEST(v1.1) applicable for three types of vehicles:
  - Garbage Truck
  - Aerial Tower
  - Cube Van

Pollutants Considered

- Greenhouse Gases
  - Carbon Dioxide (CO_2)
  - Methane (CH_4)
  - Nitrous Oxide (N_2O)
  - Carbon Dioxide Equivalent (CO_2e)
- Criteria Air Contaminants
  - Carbon Monoxide (CO)
  - Oxides of Nitrogen (NO_X)
  - Non-methane Hydrocarbons (NMHC)
  - Sulphur Dioxide (SO_2)
  - Particulate matter (PM)

Input Variables

- Vehicle Technology
- Vehicle Year
- Meet Future Year Emission Standard
- Life Span (Years)
- Capacity (cubic yard/ trip) and Number of Round Trips/Year
- Annual Operating Distance (km) and Time (hours)
- Cost Data
  - Vehicle Purchase Cost ($)
  - Resale Value ($)
  - Annual Maintenance Costs ($/year)
  - Annual Operating Costs (Fuel) ($)
  - Other Annual Costs ($)

Vehicle Technology

- Garbage Trucks (Class 8A)
  - Diesel
  - HLA
  - CNG and CNG-LFG
  - Soy B5, B10, B20 and B100
- Aerial Tower (Class 8A)
  - Diesel
  - Hybrid-Diesel
  - Soy B5, B10, B20 and B100
- Cube Vans (Class 4)
  - Gasoline
  - Hybrid-Gasoline

Emission Estimation Method

- Development of a site-specific tailpipe emission factors for heavy-duty vehicles
  - MOBILE6.2
  - European database
  - Other literature
- Life Cycle Analysis using GHGenius 3.17 model for Ontario

Tailpipe Emission Rates

- Emission factor in g/(bhp-hr) by vehicle class and fuel (e.g., gasoline and diesel)
- Multiplied by Conversion Factor to calculate in g/mi

$$\text{Conversion Factor (bhp-hr/mi)} = \frac{\text{Fuel Density (lb/gal)}}{\text{BSFC (lb/bhp-hr)} \times \text{Fuel Economy (mi/gal)}}$$

- Driving cycle based emission factors for garbage trucks
- Speed dependent emission factors for Aerial Tower and Cube Vans

Life Cycle Analysis

- Consists of emissions from
  - Tailpipe
  - Upstream
  - Carbon in end-use fuel from CO_2 in air
  - Vehicle assembly and transport
  - Materials in vehicles
- Depends upon
  - Geographical area
  - Source of fuel
  - Fuel type
  - vehicle class
  - Technology

Example of using GVEST

- 10 different types of Garbage Trucks
- Results do not reflect the costs and emissions from City of Toronto's fleet
- Hypothetical results
- Should not be used in decision making

Example Start Page

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Green Vehicle Evaluation and Selection Tool (GVESTv1.1)

The Green Vehicle Evaluation and Selection Tool (GVEST) is an Excel-based tool that has been developed to assist the City of Toronto's Fleet Services Division (FSD) in selecting lower-emission technologies for medium- and heavy-duty vehicles. Vehicle options are compared based on greenhouse gas (GHG) emissions, criteria air contaminant (CAC) emissions, fuel economy and lifetime costs. Pollutant emission results are given as both tailpipe and lifecycle emissions. The current version GVEST (v1.1) can be used to compare green options for garbage/recycling collection trucks, aerial towers and cube vans.

The City of Toronto is making the GVEST available to all public and private fleet managers to assist them in selecting green vehicle options. The tool can be customized by the fleet manager to describe a fleet's specific operational requirements and select green vehicles that meet those needs. A user's guide providing step-by-step instructions is available. Fleets anywhere in North America can use GVEST to analyse green options for their fleet based on tailpipe emissions, but GVEST results for lifecycle emissions of pollutants should only be used by fleets in Ontario, Canada. In addition to garbage trucks, aerial towers and cube vans, other medium- and heavy-duty vehicle types can be added to the tool by contacting Dr. Rakesh Singh at ENVIRON EC (Canada) Inc. (rsingh@environcorp.com).

The GVEST model offers sophisticated emissions modelling for GHGs and CACs. Users should keep in mind that the cost analysis in GVEST takes a simple approach and is intended to give only a rough indication of comparative lifetime costs. Fleet managers can use the GVEST results as a guide to the best green technologies for their fleet, but should verify cost estimates with up-to-date data for their geographic location before making a final purchasing decision.

The current version of GVEST provides a framework that fleet managers can use to compare green vehicle options. Over 2010-2011, the City of Toronto will be monitoring its hybrid garbage trucks, aerial towers and cube vans and comparing them with conventional (non-hybrid) models. The real-world performance results for Toronto's green vehicles will be incorporated into the next version of GVEST, and it will be made publicly available.

The development of the GVEST, and the monitoring of Toronto's green vehicles, are funded by the Toronto Atmospheric Fund (www.toronto.ca/taf).

GHG and CAC estimation algorithms were developed by ENVIRON using information for tailpipe emissions including correction factors for driving cycle and operating conditions from the following sources: US EPA's MOBILE6.2 model, the US National Renewable Energy Laboratory, the European Union's EMEP/CORINAIR Emission Inventory Guidebook (2007), The Climate Registry's General Reporting Protocol (2008), as well as other published data. Lifecycle information for "Upstream" fuel use, "Vehicle assembly and transport"; as well as "Materials used in the vehicles" was collected from Natural Resources Canada's GHGenius model version 3.17.

DISCLAIMER

Green Vehicle Evaluation and Selection Tool ("GVEST") was developed under contract to the City of Toronto ("the City") for use by the City and is owned by the City. Your use of GVEST is at your sole risk. The City and its consultant ENVIRON EC (CANADA), INC. (ENVIRON) do not warrant or in any way represent GVEST's merchantable quality, fitness or adequacy for a particular purpose or use, quality, productiveness or capacity. The City and ENVIRON also do not warrant or in anyway represent that the operation of GVEST will be error-free or problem-free, that no viruses or other contaminating or destructive properties will be transmitted or that no damage will occur to your computer system through use of GVEST.

The City, its elected and appointed officials, employees or agents and ENVIRON, its officers, directors, employees, agents, consultants and sub-consultants shall not in any circumstances be liable to you or anyone else for any damages or expenses of any type arising out your use of, or inability to use, GVEST.

Step 1: Ensure Macros are enabled
Step 2: Select a Vehicle
Step 3: Click to Continue

(See User Guide for Details)

Garbage Truck | Aerial Truck | Cube Van Garbage_Truck

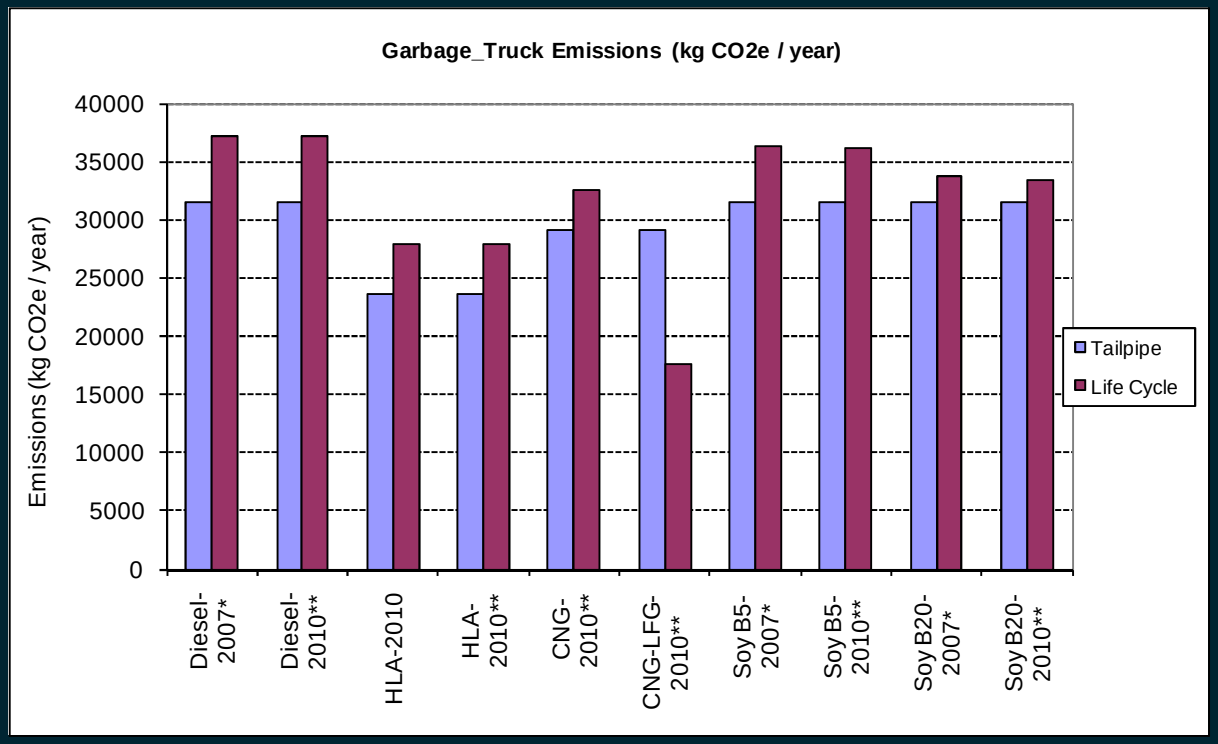
Click here to continue

For any questions about this tool, please contact Dr. Rakesh Singh at rsingh@environcorp.com

Example Input variables

Select or Enter INPUT Variables (Gold Cells Only) for Garbage_Truck													
Vehicle No.	Vehicle Technology	Vehicle Year	Meet Future Year Emission Standard?	Life Span (Years)	Capacity (cubic yard/ trip)	Number of Round Trips/Year	Annual Operating Distance (km)	Annual Operating Time (hours)	Vehicle Purchase Cost ($)	Resale Value ($)	Average Annual Maintenance Costs ($)	Average Annual Operating Costs (Fuel) ($)	Average Other Annual Costs ($)
1	Diesel	2007	2007 Compliant	7	27	420	15,000	2,000	$260,000	$20,000	$12,000	$11,600	$0
2	Diesel	2010	2010 Compliant	7	27	420	15,000	2,000	$275,000	$20,000	$12,000	$11,600	$0
3	HLA	2010	Not 2010 Compliant	7	27	420	15,000	2,000	$325,000	$25,000	$12,000	$8,700	$0
4	HLA	2010	2010 Compliant	7	27	420	15,000	2,000	$340,000	$25,000	$12,000	$8,700	$0
5	CNG	2010	2010 Compliant	7	27	420	15,000	2,000	$325,000	$25,000	$12,000	$9,976	$0
6	CNG-LFG	2010	2010 Compliant	7	27	420	15,000	2,000	$325,000	$25,000	$12,000	$9,976	$0
7	Soy B5	2007	2007 Compliant	7	27	420	15,000	2,000	$260,000	$20,000	$12,000	$12,000	$0
8	Soy B5	2010	2010 Compliant	7	27	420	15,000	2,000	$275,000	$20,000	$12,000	$12,000	$0
9	Soy B20	2007	2007 Compliant	7	27	420	15,000	2,000	$260,000	$20,000	$12,000	$13,200	$0
10	Soy B20	2010	2010 Compliant	7	27	420	15,000	2,000	$275,000	$20,000	$12,000	$13,200	$0

Example – CO_2e Emissions



Notes:
(1)Vehicle with no data is not applicable;
(2)* shows that vehicle with model years between 2004 and 2007 are compliant with the USEPA's 2007 emission standards;
(3) ** shows that vehicle with model years between 2007 and 2010 are compliant with the USEPA's 2010 emission standards.

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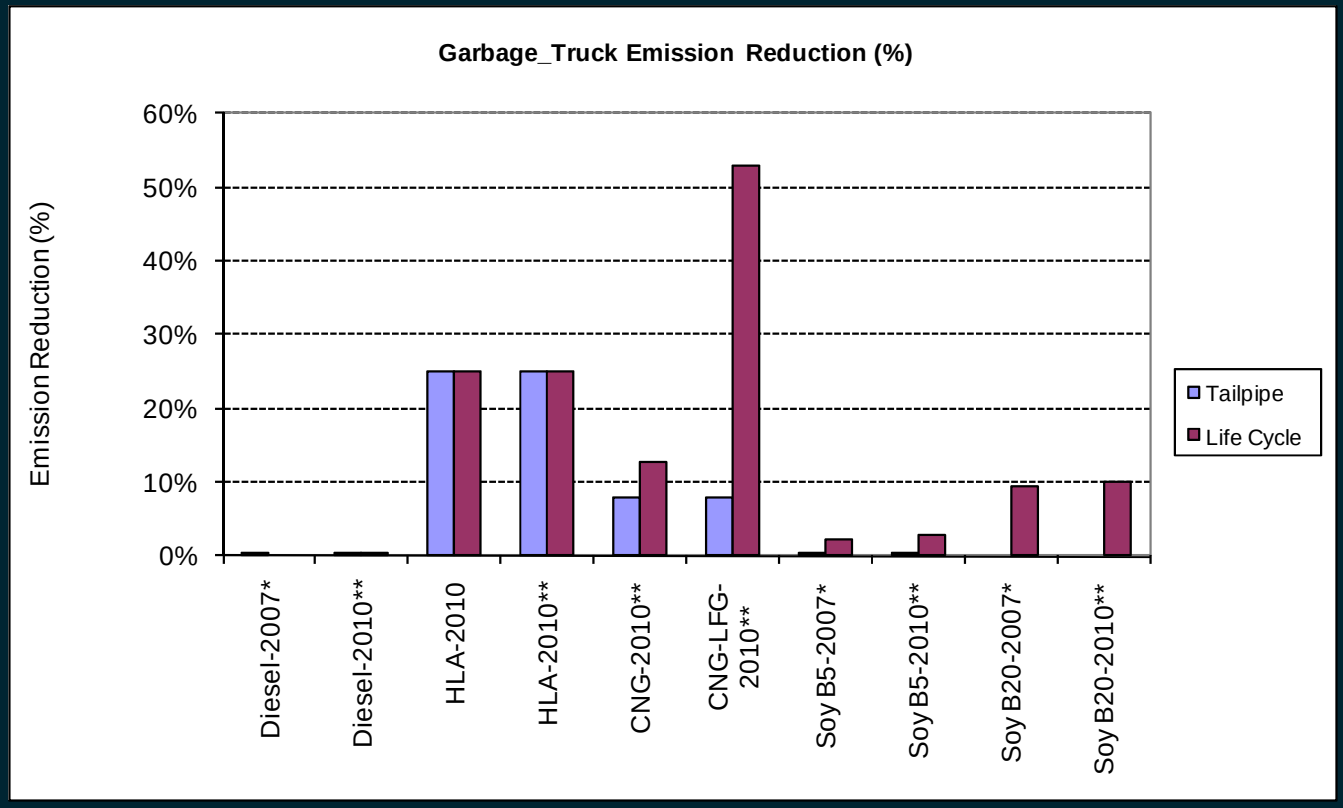
Example – CO_2e Reduction



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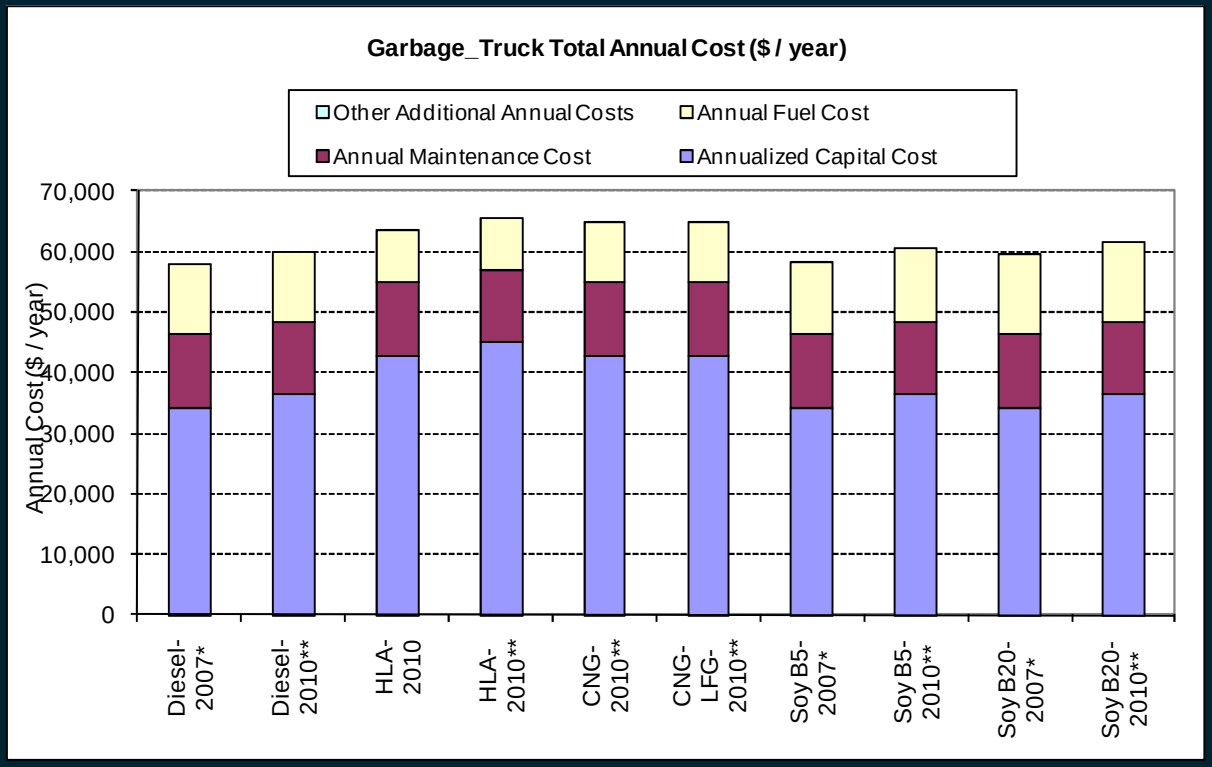
Example – Cost and Fuel



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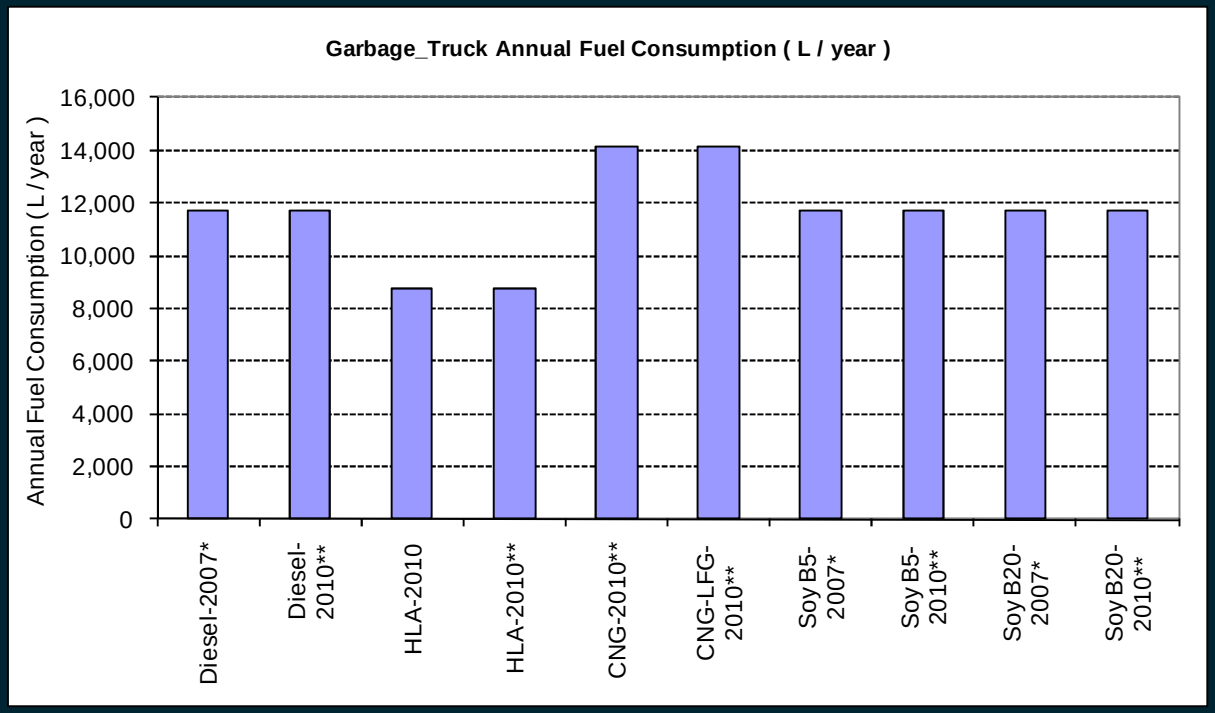
Example – Fuel Consumption



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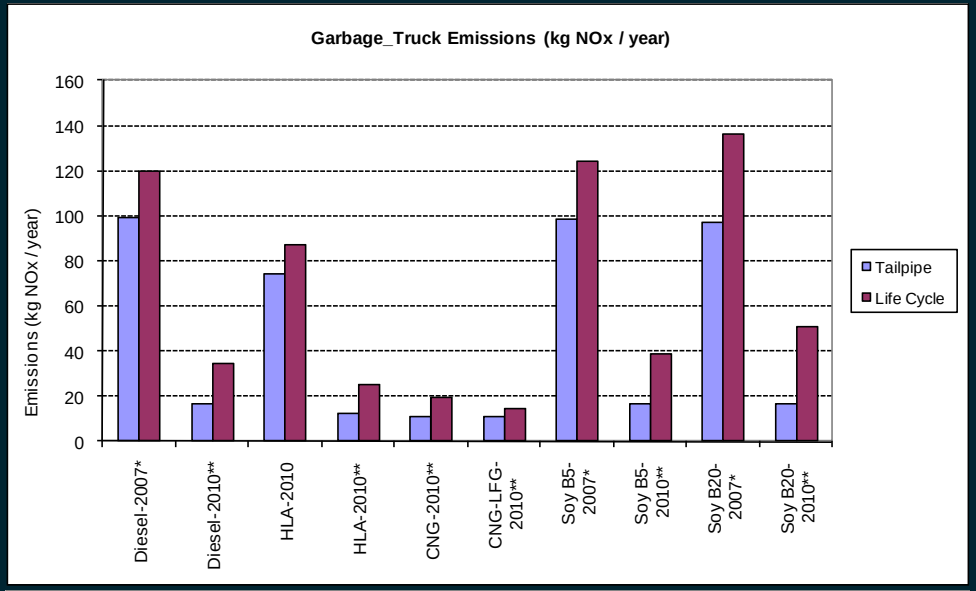
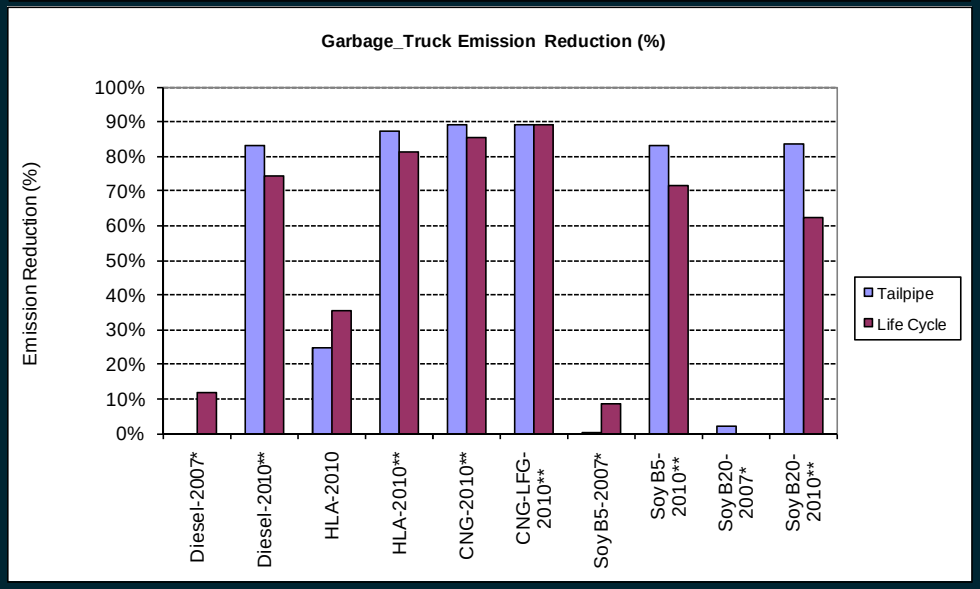
Example – NO_X Emissions





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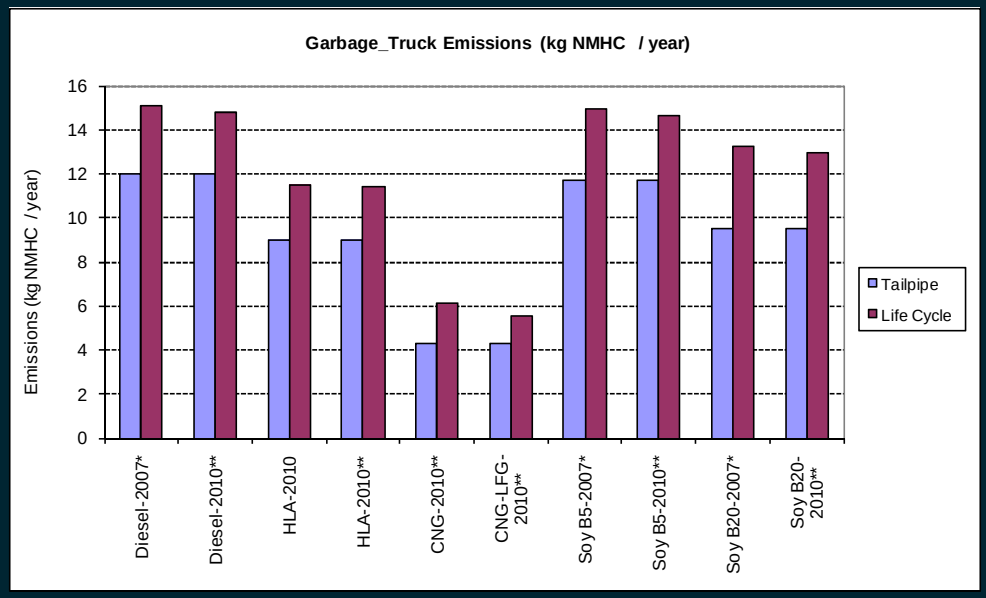
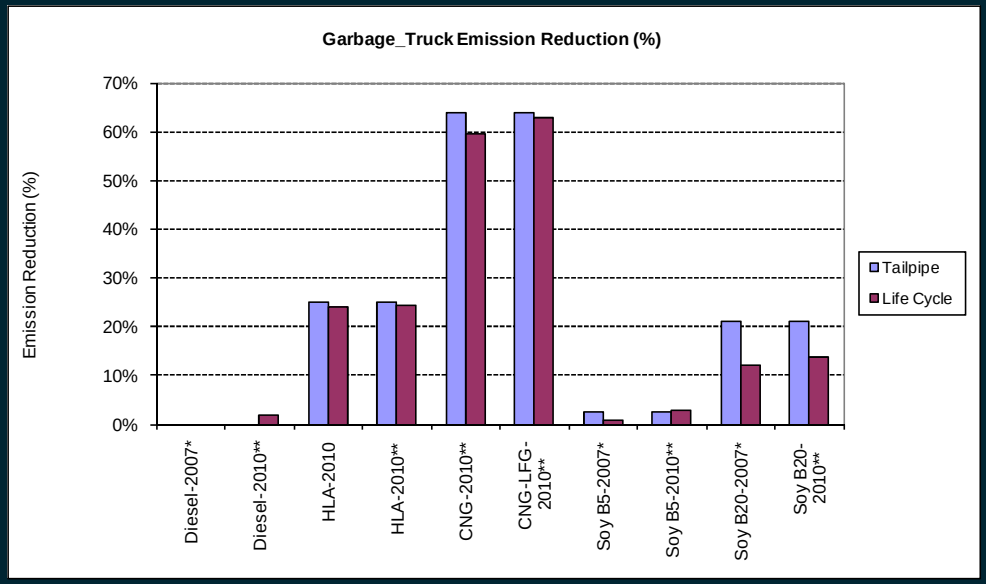
Example – NMHC Emissions





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Example – Result summary page

- Vehicle ID
- Fuel Economy (diesel-litre-equivalent/ 100km)
- Fuel Economy (diesel-litre-equivalent/ year)
- Life Cycle Emissions of CO_2e (kg/year)
- Life Cycle CO_2e Emission Reduction (%)
- Life Cycle Emissions of NO_X (kg/year)
- Life Cycle NOX Emission Reduction (%)
- Life Cycle Emissions of NMHC (kg/year)
- Life Cycle NMHC Emission Reduction (%)
- Average Annual Cost of Operation ($)
- Increase in Average Annual Cost (%)

Example – Result summary page

Fuel Economy and Emission Analysis Summary for Garbage_Truck											
Vehicle No.	Vehicle ID	Fuel Economy (diesel-litre-equivalent/ 100km)	Fuel Economy (diesel-litre-equivalent/ year)	Life Cycle Emissions of CO2e (kg/year)	Life Cycle CO2e Emission Reduction (%)	Life Cycle Emissions of NOx (kg/year)	Life Cycle NOx Emission Reduction (%)	Life Cycle Emissions of NMHC (kg/year)	Life Cycle NMHC Emission Reduction (%)	Average Annual Cost of Operation ($)	Increase in Average Annual Cost (%)
1	Diesel-2007*	77.9	11,681	37,224	0.0%	119.7	11.9%	15.1	0.0%	$57,886	0.0%
2	Diesel-2010**	77.9	11,681	37,095	0.3%	34.7	74.5%	14.8	1.9%	$60,029	3.7%
3	HLA-2010	58.4	8,761	27,930	25.0%	87.4	35.6%	11.5	23.9%	$63,557	9.8%
4	HLA-2010**	58.4	8,761	27,912	25.0%	25.5	81.2%	11.4	24.2%	$65,700	13.5%
5	CNG-2010**	94.2	14,134	32,457	12.8%	19.8	85.5%	6.1	59.5%	$64,833	12.0%
6	CNG-LFG-2010**	94.2	14,134	17,547	52.9%	14.7	89.2%	5.6	63.0%	$64,833	12.0%
7	Soy B5-2007*	77.9	11,681	36,333	2.4%	124.0	8.7%	14.9	0.9%	$58,286	0.7%
8	Soy B5-2010**	77.9	11,681	36,178	2.8%	38.8	71.4%	14.6	2.7%	$60,429	4.4%
9	Soy B20-2007*	77.9	11,681	33,659	9.6%	135.9	0.0%	13.2	12.1%	$59,486	2.8%
10	Soy B20-2010**	77.9	11,681	33,428	10.2%	51.2	62.3%	13.0	13.8%	$61,629	6.5%

Vehicle ID Note: * shows that vehicle with model years between 2004 and 2007 are compliant with the USEPA's 2007 emission standards
** shows that vehicle with model years between 2007 and 2010 are compliant with the USEPA's 2010 emission standards

This table summarizes the overall results of this analysis. It can be used to guide purchasing decisions, based on the fleet manager's priorities.

1. The best-ranking result in each column is shaded bright green.
2. The second-best result in each column in shaded light green.

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Next Steps

- This demonstration shows the potential of the tool for guiding green vehicle purchasing decisions.
- FSD is currently monitoring the performance of its heavy-duty vehicles.
- The GVEST will be updated with input data from these vehicles to provide real-world results.

Acknowledgement

Authors would like to thank the Toronto Atmospheric Fund for their funding to support the development of GVEST.

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