

User Guide for AFLEET Tool 2016

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NOTATION

Acronyms and Abbreviations

AFLEET	Alternative Fuel Life-Cycle Environmental and Economic Transportation
AFV	alternative fuel vehicle
Argonne	Argonne National Laboratory
B100	blend of 100% biodiesel by volume
B20	blend of 20% biodiesel and 80% diesel by volume
CD	charge depleting
CNG	compressed natural gas
CO	carbon monoxide
DEF	diesel exhaust fluid
DOE	U.S. Department of Energy
E85	blend of 85% ethanol and 15% gasoline by volume
EPA	Environmental Protection Agency
EREV	extended range electric vehicle
EV	all-electric vehicle
FCV	fuel cell vehicle
G.H ₂	gaseous hydrogen
GHG	greenhouse gas
REET	Greenhouse gases, Regulated Emissions, and Energy Use in Transportation
HDV	heavy-duty vehicle
HEV	hybrid electric vehicle
HHV	hydraulic hybrid vehicle
LDV	light-duty vehicle
LNG	liquefied natural gas
LPG	liquefied petroleum gas
MOVES	Motor Vehicle Emission Simulator
NO _x	nitrogen oxides
PHEV	plug-in hybrid electric vehicle
PM ₁₀	particulate matter with a diameter of 10 micrometers or less
PM _{2.5}	particulate matter with a diameter of 2.5 micrometers or less
PTW	pump-to-wheels

TBW	tire and brake wear
TCO	total cost of ownership
VOC	volatile organic compound
WTP	well-to-pump
WTW	well-to-wheels

Units of Measure

GGE	gasoline gallon equivalent
MPDGE	mile(s) per diesel gallon equivalent
MPGGE	mile(s) per gasoline gallon equivalent

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1. BACKGROUND

Beginning in 1998, the Department of Energy's (DOE's) Clean Cities program enlisted expertise at Argonne National Laboratory (Argonne) to develop a U.S. Environmental Protection Agency (EPA) co-sponsored tool to assist metropolitan areas and Clean Cities coalitions in estimating criteria air pollutant reductions achieved by near-term introduction of alternative-fueled vehicles. Known as AirCRED, the tool was designed to be used by stakeholders of DOE's Clean Cities program to assist state and regional air quality officials with developing ozone precursor and carbon monoxide emission reduction strategies for use in State Implementation Plans. In 2009, DOE requested Argonne to develop a calculator to measure the petroleum displacement and greenhouse gas (GHG) emissions of medium- and heavy-duty alternative fuel vehicles and off-road equipment. Known as the GREET Fleet Footprint Calculator, this tool was developed for Clean Cities stakeholders to estimate these values using simple spreadsheet inputs.

Now in accordance with the desire to measure both the environmental and economic costs and benefits of alternative fuel and advanced vehicles (AFVs), Argonne has developed the Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) Tool. Building on both AirCRED and GREET Fleet, AFLEET Tool allows Clean Cities stakeholders to estimate life-cycle petroleum use, life-cycle greenhouse gas emissions, vehicle operation air pollutant emissions, and costs of ownership for light-duty vehicles (LDVs) and heavy-duty vehicles (HDVs). AFLEET Tool provides three calculation methods depending on the user's goals.

The first option is the Simple Payback Calculator that examines acquisition and annual operating costs to calculate a simple payback for purchasing a new AFV as compared to its conventional counterpart, as well as average annual petroleum use, GHGs, and air pollutant emissions. The second option is the Total Cost of Ownership (TCO) Calculator that evaluates the net present value of operating and fixed costs over the years of planned ownership of a new vehicle, as well as lifetime petroleum use, GHGs, and air pollutant emissions. Finally, the Fleet Energy and Emissions Footprint Calculator estimates the annual petroleum use, GHGs, and air pollutant emissions of existing and new vehicles, taking into consideration that older vehicles typically have higher air pollutant emission rates than newer ones.




2. DESCRIPTION OF AFLEET TOOL

There are nine Microsoft® Excel sheets in the calculator, which are explained below.

2.1 Instructions Sheet

This sheet contains the software copyright notice and it presents a brief summary of cell types (Figure 1) and other worksheets in AFLEET Tool.

Figure 1. Instructions Sheet – Cell Color Scheme

	Yellow cells are key assumptions that users can change with their data
	Orange cells are key options that users will select from a drop-down
	Clear cells are for calculations and secondary assumptions

2.2 Inputs Sheet

The essential user inputs (Figure 2) for both the Simple Payback and Total Cost of Ownership calculators (the Fleet Energy and Emissions Footprint Calculator also uses the specified vehicle location for its air pollutant calculations) are:

- **primary vehicle location (state and county)**
- **vehicle type**
- **vehicle fuel type**
- **number of vehicles**
- **annual vehicle mileage**
- **fuel economy**
- **vehicle purchase price**
- **public or private fuel station pricing**
- **fuel and diesel emission fluid (DEF) price.**

Argonne has provided default data for many inputs in AFLEET Tool; however, it is highly recommended that users enter their own data whenever possible. However, the user must enter the number of vehicles to be compared as the default is set to zero. When estimating a simple payback, the user must enter data for both the AFVs and their conventional counterpart (e.g. gasoline vehicle for LDVs and diesel vehicle for HDVs). When entering their own data, users need to enter the fuel economy values on a mile per gasoline gallon equivalent (MPGGE) basis for LDVs and on a mile per diesel gallon equivalent (MPDGE) fuel economy basis for HDVs. We provide fuel economy ratios as compared to the conventional vehicle baseline (gasoline for LDVs and diesel for HDVs) to the right of the key inputs table to help with adjust AFV fuel economy values. Default fuel pricing is based on the station type (public or private) and the state selected.

Figure 2. Inputs Sheet - Key Inputs

Primary Vehicle Location				
State	CALIFORNIA			
County	LOS ANGELES			
Light-Duty Vehicle Information				
Vehicle Type	Passenger Car			
Light-Duty Fuel Type	Number of Light-Duty Vehicles	Annual Vehicle Mileage	Fuel Economy (MPGGE)	Purchase Price (\$/Vehicle)
Gasoline	0	12,400	28.8	\$20,000
Diesel	0	12,400	34.6	\$22,500
Gasoline Hybrid Electric Vehicle (HEV)	0	12,400	40.3	\$23,000
Gasoline Plug-in Hybrid Electric Vehicle (PHEV)	0	12,400	42.9	\$32,500
Gasoline Extended Range Electric Vehicle (EREV)	0	12,400	41.2	\$34,000
All-Electric Vehicle (EV)	0	12,400	95.0	\$30,000
Gaseous Hydrogen (G.H2) Fuel Cell Vehicle (FCV)	0	12,400	57.3	\$58,500
Biodiesel (B20)	0	12,400	34.6	\$22,500
Biodiesel (B100)	0	12,400	34.6	\$22,500
Ethanol (E85)	0	12,400	28.8	\$20,000
Propane (LPG)	0	12,400	28.8	\$26,000
Compressed Natural Gas (CNG)	0	12,400	27.4	\$27,000
Heavy-Duty Vehicle Information				
Vehicle Type	Single Unit Short-Haul Truck			
Heavy-Duty Fuel Type	Number of Heavy-Duty Vehicles	Annual Vehicle Mileage	Fuel Economy (MPDGE)	Purchase Price (\$/Vehicle)
Gasoline	0	0	6.2	\$0
Diesel	0	16,500	7.4	\$65,000
All-Electric Vehicle (EV)	0	16,500	20.4	\$150,000
Gaseous Hydrogen (G.H2) Fuel Cell Vehicle (FCV)	0	0	12.2	\$0
Diesel Hybrid Electric Vehicle (HEV)	0	16,500	9.4	\$105,000
Diesel Hydraulic Hybrid (HHV)	0	0	9.5	\$0
Biodiesel (B20)	0	16,500	7.4	\$65,000
Biodiesel (B100)	0	16,500	7.4	\$65,000
Ethanol (E85)	0	0	6.2	\$0
Propane (LPG)	0	0	6.2	\$0
Compressed Natural Gas (CNG)	0	16,500	6.3	\$105,000
Liquefied Natural Gas (LNG)	0	16,500	6.3	\$95,000
LNG / Diesel Pilot Ignition	0	0	7.0	\$0
Refueling Information				
Fueling Type	Private Station		For infrastructure costs, go to 'Payback' sheet	
Fuel Price Sensitivity	No		To enter fuel price range, go to 'Payback' sheet	
Fuel and DEF Price				
		Public Station	Private Station	
	Fuel Unit	(\$/Fuel Unit)		
Gasoline	gasoline gallon	\$3.01	\$2.84	
Diesel	diesel gallon	\$3.04	\$3.03	
Electricity	kWh	\$0.16	\$0.16	
G.H2	hydrogen kg	\$20.29	\$6.99	
B20	B20 gallon	\$2.92	\$2.70	
B100	B100 gallon	\$3.94	\$4.41	
E85	E85 gallon	\$2.59	\$2.56	
Propane	LPG gallon	\$3.01	\$2.63	
CNG	CNG GGE	\$2.43	\$1.96	
LNG	LNG gallon	\$2.86	\$2.11	
Diesel Exhaust Fluid (DEF)	DEF gallon	\$2.80	\$2.80	

The vehicle types in AFLEET Tool are based on EPA's Motor Vehicle Emission Simulator (MOVES) as this allows the tool to estimate vehicle operation (e.g. tailpipe, brake and tire wear) emissions for various vehicle vocations (EPA 2016). Each vehicle type has default vocational data that populate the cells. This information is available in lookup tables on the Background Data sheet. As discussed in Section 2.9 of this document, a user can click the blue hyperlink for "Vehicle Type" and modify the default vocation type using the dropdown boxes. The current light-duty vehicle types available in AFLEET Tool are:

- **passenger car** (four wheel, two axle vehicle whose primary function is passenger transport)
- **passenger truck** (four wheel, two axle vehicle whose primary functional design is for cargo, but are used primarily for passenger transport)
- **light commercial truck** (four wheel, two axle vehicle used primarily for cargo transport).

While the heavy-duty vehicle types are:

- **school bus** (passenger vehicle with a capacity of 15 or more persons used primarily for transport of students for school)
- **transit bus** (passenger vehicle with a capacity of 15 or more persons primarily used for transport within cities)
- **refuse truck** (truck primarily used to haul refuse to a central location)
- **single unit short-haul truck** (single unit truck with more than four tires with a range of operation of up to 200 miles)
- **single unit long-haul truck** (single unit truck with more than four tires with a range of operation of over 200 miles)
- **combination short-haul truck** (combination tractor/trailer truck with more than four tires with a range of operation of up to 200 miles)
- **combination long-haul truck** (combination tractor/trailer truck with more than four tires with a range of operation of over 200 miles).

The current light-duty vehicle fuel types available in AFLEET Tool are:

- **gasoline**
- **diesel**
- **gasoline hybrid electric vehicle (HEV)**
- **gasoline plug-in hybrid electric vehicle (PHEV)**
- **gasoline extended range electric vehicle (EREV)**
- **all-electric vehicle (EV)**
- **gaseous hydrogen (G.H2) fuel cell vehicle (FCV)**
- **biodiesel 20% blend (B20)**
- **biodiesel 100% blend (B100)**
- **ethanol flex-fuel 85% blend (E85)**
- **propane / liquefied petroleum gas (LPG)**
- **compressed natural gas (CNG).**

While the heavy-duty vehicle fuel types are:

- **gasoline**
- **diesel**

- EV
- G.H2 FCV
- diesel HEV
- diesel hydraulic hybrid vehicle (HHV)
- B20
- B100
- E85
- LPG
- CNG
- liquefied natural gas (LNG)
- liquefied natural gas / diesel pilot ignition.

If one wants to perform TCO calculations (Figure 3), the user can modify the:

- planned years of ownership
- whether purchase is financed by a loan
- loan term
- loan interest rate
- discount factor.

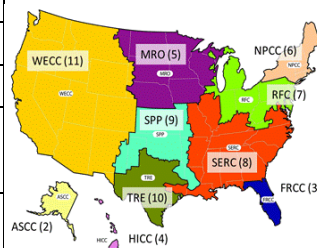
Figure 3. Inputs Sheet - Total Cost of Ownership Inputs

Light-Duty Vehicle Information			
Years of Planned Ownership	years	15	
Heavy-Duty Vehicle Information			
Years of Planned Ownership	years	15	
Infrastructure Information			
Years of Planned Ownership	years	15	
Financial Assumptions			
		Vehicles	Infrastructure
Loan	yes/no	No	No
Loan Term	years	5	5
Interest Rate	%	3.37%	3.37%
Percent Down Payment	%	0.00%	0.00%
Discount Factor	%	0.83%	

The user can also modify the fuel production assumptions (Figure 4), which will impact the petroleum use and GHG calculations. For instance, a user can compare the footprint of ethanol vehicles using either a corn or cellulosic feedstock. A user who wants to enter a custom electricity generation mix will need to go to Background Data sheet. If one clicks the blue hyperlink for the “12 – User Defined” mix in the fuel production assumptions table, the user will be taken to the correct cells to enter the new values.

Figure 4. Inputs Sheet – Fuel Production Assumptions

Biodiesel Feedstock Source	1 - Soy 2 - Algae	1
Ethanol Feedstock Source	1 - Corn 2 - Switchgrass	1
CNG Feedstock Source	1 - North American NG 2 - Renewable NG - Wastewater Treatment 3 - Landfill Gas	1
LNG Feedstock Source	1 - North American NG 2 - Renewable NG - Wastewater Treatment 3 - Landfill Gas	1
North American NG Feedstock Source	Conventional 66%	Shale 34%
LPG Feedstock Source	NG 69%	Petroleum 31%
Source of Electricity for PHEVs, EVs, and FCVs (Electrolysis)	1 - Average U.S. Mix 2 to 11 - EIA Region Mix (see map) 12 - User Defined (go to 'Background Data' sheet)	1
G.H2 Production Process	1 - Refueling Station SMR (On-site) 2 - Central Plant SMR (Off-site) 3 - Refueling Station Electrolysis (On-site)	1



2.3 Payback Sheet

This sheet contains the Simple Payback Calculator, which examines acquisition and annual operating costs as well as average annual petroleum use, GHGs, and air pollutant emissions. The vehicle operation air pollutant emissions calculated are:

- **carbon monoxide (CO)** from tailpipe
- **nitrogen oxides (NO_x)** from tailpipe
- **particulate matter with a diameter of 10 micrometers or less (PM₁₀)** from tailpipe and tire and brake wear (TBW)
- **particulate matter with a diameter of 2.5 micrometers or less (PM_{2.5})** from tailpipe and TBW
- **VOCs (volatile organic compounds)** from tailpipe and evaporation.

Key assumptions for light-duty vehicles, heavy-duty vehicles, and fuel price from the Inputs sheet are fed into the first three tables in the Payback sheet (Figure 5). Additional user inputs can be modified on this sheet for the fuel consumption of charge depleting (CD) operation of PHEVs and EREVs, vehicle purchase incentive, maintenance and repair cost per mile, share of LNG fuel use in a LNG diesel pilot ignition vehicle, DEF consumption, fuel price sensitivity, and infrastructure costs.

Figure 5. Payback Sheet – LDVs, HDVs, and Fuel Inputs

	Gasoline	Diesel	Gasoline HEV	Gasoline PHEV	Gasoline EREV	EV	G.H2 FCV	Diesel HEV	Diesel HHV	B20	B100	E85	LPG	CNG	LNG	Diesel Pilot Ignition
Light-Duty Vehicle Inputs																
Vehicle Type	Passenger Car															
Number of LDVs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Mileage	12,400	12,400	12,400	12,400	12,400	12,400	12,400	12,400	12,400	12,400	12,400	12,400	12,400	12,400	12,400	12,400
Fuel Economy (MPGGE)	28.8	34.6	40.3	42.9	41.2	95.0	57.3			34.6	34.6	28.8	28.8	27.4		
CD Electricity Use (kWh/100mi)				23.0	31.2		34.6									
CD Electricity Use (GGE/100mi)				0.7	1.0											
CD Gasoline Use (GGE/100mi)				0.7	0.0											
PHEV CD Range (miles)				19.6	34.0											
Charges/day				1.0	1.0											
Days driven/week				5	5											
Share of CD miles				41%	71%											
Share of Alternative Fuel Use in Dual-Fuel or PHEV (Energy %)				15%	50%											
DEF Use (% of fuel consumption)	0%	2%	0%	0%	0%	0%	0%			2%	2%	0%	0%	0%		
Purchase Price (\$/vehicle)	\$20,000	\$22,500	\$23,000	\$32,500	\$34,000	\$30,000	\$58,500			\$22,500	\$22,500	\$20,000	\$26,000	\$27,000		
Incentive (\$/vehicle)	\$0	\$0	\$0	\$0	\$0	\$0	\$0			\$0	\$0	\$0	\$0	\$0		
Maintenance & Repair (\$/mile)	\$0.142	\$0.192	\$0.137	\$0.135	\$0.135	\$0.125	\$0.125			\$0.192	\$0.192	\$0.142	\$0.142	\$0.142		
Heavy-Duty Vehicle Inputs																
Vehicle Type	Single Unit Short-Haul Truck															
Number of HDVs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Mileage	0	16,500	0	0	0	16,500	0	16,500	0	16,500	16,500	0	0	16,500	16,500	0
Fuel Economy (MPGGE)	5.3	6.4				17.6	10.6	8.1	8.3	6.4	6.4	5.3	5.3	5.4	5.4	6.1
Share of Alternative Fuel Use in Dual-Fuel or PHEV (Energy %)																95%
DEF Use (% of fuel consumption (GGE))	0%	2%				0%	0%	2%	2%	2%	2%	0%	0%	0%	0%	2%
Purchase Price (\$/vehicle)	\$0	\$65,000				\$150,000	\$0	\$105,000	\$0	\$65,000	\$65,000	\$0	\$0	\$105,000	\$95,000	\$0
Incentive (\$/vehicle)	\$0	\$0				\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Maintenance & Repair (\$/mile)	\$0.201	\$0.201				\$0.139	\$0.139	\$0.158	\$0.158	\$0.201	\$0.201	\$0.201	\$0.201	\$0.216	\$0.216	\$0.222

On the Inputs sheet, the user can enter the charge sustaining (i.e. hybrid mode) fuel economy of PHEVs and EREVs. While on the Payback sheet, users will need to examine further inputs to make sure they are properly analyzing these vehicles. These include the CD electricity and fuel consumption, CD operating range, charges per day, and days driven per week, which are all used to estimate the amount of electricity and gasoline used by these vehicles.

The electricity and fuel use inputs for CD operation of PHEVs and EREVs are on a fuel consumption basis (i.e. electricity and gasoline per 100 miles driven, instead of miles per gallon). These values will be found on FuelEconomy.gov on this basis. CD operation (i.e. EV mode) occurs when the vehicle is dependent on the using the battery for operation and the battery's state of charge depletes. In AFLEET Tool, we allow the user to separately simulate PHEVs and EREVs. While an EREV is a type of PHEV, the key difference that we used to differentiate them for AFLEET Tool is that an EREV operates all electrically until the battery is depleted and will typically have a large battery pack than a PHEV. With current battery technology, PHEVs other than EREVs typically operate in blended CD mode, which is when the battery's energy is primarily used to drive the vehicle but the engine may turn on to assist driving the vehicle (e.g. during hard accelerations). Therefore, PHEVs may have CD gasoline use, while EREVs will not.

Default maintenance (scheduled) and repair (unscheduled) costs on a per mile basis are included for each vehicle type. Though again, it is highly recommended that users enter their own data whenever possible as this cost data will depend on the individual fleet/operator. The incremental maintenance and repair cost difference between various vehicle types is typically small as we usually assume similar costs. In some cases, we do calculate differences as hybrids and electric drive vehicles (i.e. PHEVs, EREVs, and EVs) may have reduced brake (and other) costs as compared to conventional vehicles. In addition, incremental maintenance costs for natural gas vehicles, such as CNG tank inspection and increased oil change intervals for heavy-duty natural gas vehicles are included. In this version, we do not include battery replacement costs for hybrids and electric drive vehicles as reliable data for replacement intervals and expected costs are not available at this time. Biodiesel has different cold weather operability as compared to diesel and may require additives or treatments to improve performance. In the current version of AFLEET Tool, no costs for these treatments are included as data was not available.

The share of LNG fuel use in a LNG / diesel pilot ignition vehicle is set to match the performance of the Westport™ high-pressure direct injection system, though other systems will have different performance. Some vehicles use selective catalytic reduction systems to reduce NO_x emissions. These systems require DEF, a urea-based solution, to operate correctly. DEF use is typically estimated as a percent of fuel consumption; users can adjust this value on this sheet. A vehicle purchase incentive can be entered on this sheet or can be included in the purchase price on the Inputs sheet.

On the Inputs sheet, the user can select whether to examine fuel price sensitivity via dropdown box. On the Payback sheet, the user can enter the values for the high and low fuel price scenarios either by percentage of default GGE or by directly entering the values on a GGE basis (Figure 6).

Figure 6. Payback Sheet – Fuel Price Sensitivity

	Gasoline	Diesel	Gasoline HEV	Gasoline PHEV	Gasoline EREV	EV	G.H2 FCV	Diesel HEV	Diesel HHV	B20	B100	E85	LPG	CNG	LNG	LNG / Diesel Pilot Ignition
Fuel Price Sensitivity																
Public Fuel Price Sensitivity Case	No															
High Fuel Price (% increase vs default)	17%	19%	17%	17%	17%	0%	0%	19%	19%	0%	0%	0%	0%	0%	0%	0%
High Primary Fuel Price (\$/GGE)	\$3.51	\$3.13	\$3.51	\$3.51	\$3.51	\$5.34	\$20.29	\$3.13	\$3.13	\$2.57	\$3.70	\$3.53	\$3.98	\$2.43	\$4.29	\$4.29
High Secondary Fuel Price (\$/GGE)																
Low Primary Fuel Price (% decrease vs default)	17%	19%	17%	17%	17%	0%	0%	19%	19%	0%	0%	0%	0%	0%	0%	0%
Low Primary Fuel Price (\$/GGE)	\$2.51	\$2.13	\$2.51	\$2.51	\$2.51	\$5.34	\$20.29	\$2.13	\$2.13	\$2.57	\$3.70	\$3.53	\$3.98	\$2.43	\$4.29	\$4.29
Low Secondary Fuel Price (\$/GGE)																
Private Fuel Price Sensitivity Case	No															
High Fuel Price (% increase vs default)	18%	19%	17%	17%	17%	0%	0%	19%	19%	0%	0%	0%	0%	0%	0%	0%
High Primary Fuel Price (\$/GGE)	\$3.34	\$3.13	\$3.31	\$3.31	\$3.31	\$5.34	\$6.99	\$3.12	\$3.12	\$2.38	\$4.14	\$3.49	\$3.47	\$1.96	\$3.17	\$3.17
High Secondary Fuel Price (\$/GGE)																
Low Primary Fuel Price (% decrease vs default)	18%	19%	17%	17%	17%	0%	0%	19%	19%	0%	0%	0%	0%	0%	0%	0%
Low Primary Fuel Price (\$/GGE)	\$2.34	\$2.13	\$2.37	\$2.37	\$2.37	\$5.34	\$6.99	\$2.13	\$2.13	\$2.38	\$4.14	\$3.49	\$3.47	\$1.96	\$3.17	\$3.17
Low Secondary Fuel Price (\$/GGE)																

Default infrastructure costs are provided, which are estimated either based on specific equipment (e.g. number of storage tanks and dispensers) for gasoline, diesel, electricity, biodiesel, and ethanol fueled vehicles or on a fuel throughput basis (i.e. how much fuel the LDVs and HDVs are calculated to use in AFLEET) for G.H2, LPG, CNG, and LNG fueled vehicles. Detailed infrastructure costs are in the Background Data sheet, which can be viewed by clicking the blue hyperlink for “Infrastructure Costs” (Figure 7). To obtain the default value, the user selects the appropriate station/EVSE type and then enters the number of stations/EVSEs to be built. For private stations, default annual operation and maintenance costs will be displayed as well. Users can enter their own data over these defaults. In addition, users can enter other infrastructure-related costs such out of route mileage and fueling labor costs.

Figure 7. Payback Sheet – Infrastructure Costs

	Gasoline	Diesel	Gasoline HEV	Gasoline PHEV	Gasoline EREV	EV	G.H2 FCV	Diesel HEV	Diesel HHV	B20	B100	E85	LPG	CNG	LNG	LNG / Diesel Pilot Ignition
Infrastructure Inputs																
Station/EVSE Type	New Private	New Private	New Private	Level 1	Level 1	Level 2 - Home	New Private	New Private	New Private	New Private	New Private	New Private	New Private	New Private	New Private	New Private
Number of stations/EVSEs	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0
Total Refueling Station/EVSE Cost	\$0	\$0	\$0	\$720	\$720	\$1,200	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Total Incentive	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Maintenance Depot Cost	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Annual Private Station/EVSE Operation & Maintenance	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Default Refueling Station/EVSE Cost	\$0	\$0	\$0	\$720	\$720	\$1,200	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Default Annual Private Station/EVSE O&M Costs (\$/yr)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Annual Private Fueling Labor & Misc. Costs (\$/yr)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Public Out of Route Mileage, Labor & Misc. Costs																
LD Annual Out of Route Mileage To Public Station	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LD Out of Route Vehicle Speed (miles/hr)	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
LD Labor Rate (\$/hr)	\$25	\$25	\$25	\$25	\$25	\$25	\$25	\$25	\$25	\$25	\$25	\$25	\$25	\$25	\$25	\$25
LD Annual Out of Route Labor Costs (\$/yr)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
LD Public Fueling Labor & Misc. Costs (\$/yr)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Private Out of Route Mileage, Labor & Misc. Costs																
HD Annual Out of Route Mileage To Public Station	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HD Out of Route Vehicle Speed (miles/hr)	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
HD Labor Rate (\$/hr)	\$25	\$25	\$25	\$25	\$25	\$25	\$25	\$25	\$25	\$25	\$25	\$25	\$25	\$25	\$25	\$25
HD Annual Out of Route Labor Costs (\$/yr)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
HD Public Fueling Labor & Misc. Costs (\$/yr)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
LD Annual Public Station Out of Route/Fueling Lab	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
HD Annual Public Station Out of Route/Fueling Lab	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
LD Annual Private Station O&M Cost (\$/yr)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
HD Annual Private Station O&M Cost (\$/yr)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0

The other tables in this sheet include the calculation for simple payback, petroleum use, GHG emissions, air pollutant emissions, and externality costs. The calculation for simple payback is based on the acquisition and annual operating costs for a new AFV as compared to its conventional counterpart. Specifically, calculating the years (and miles) needed for the operating savings to payback the higher incremental acquisition cost. In cases where the operating costs for the AFV are higher than the costs of the conventional vehicle, there will be no payback calculated. In AFLEET Tool 2016, incremental vehicle purchase and infrastructure costs are included for acquisition costs.

The petroleum use and GHG calculations are both well-to-wheels (WTW) (i.e. life-cycle) estimates and similar to those in the GREET Fleet tool. The basis of these calculations is Argonne's Greenhouse gases, Regulated Emissions, and Energy use in Transportation (GREET) fuel-cycle model, which is used to generate necessary petroleum use and GHG emission coefficients (Argonne 2015). A WTW analysis can be divided into two stages: well-to-pump (WTP) and pump-to-wheels (PTW). The WTP stage starts with the fuel feedstock recovery, followed by fuel production, and ends with the fuel available at the pump, while the PTW stage represents the vehicle's operation activities. It is important to examine petroleum use and GHG emissions of transportation fuels and technologies on a WTW basis in order to properly compare alternatives, as activities upstream of vehicle operation can use significant amounts of energy and subsequently produce a large amount of emissions. The location of where the petroleum is used or GHGs are emitted does not significantly alter their impacts.

However, for air pollutants the location where they are emitted does play a major role as they impact local air quality. Thus, air quality management organizations and other Clean Cities stakeholders are primarily interested in vehicle operation emissions, as WTP emissions often occur a significant distance from where the vehicle is used. For those interested in WTP air pollutant emissions, see the GREET fuel-cycle model. EPA's MOVES is used to generate emission factors by state for gasoline and diesel vehicle types. In some cases, there are no emissions data for vehicles as they are not available in the marketplace (e.g. no gasoline refuse or combination trucks) and therefore in AFLEET Tool the calculation will show the not applicable error sign "#N/A".

The state emission factors used in the emission calculations are based on a new vehicle (model year 2016 for AFLEET Tool 2016). However, for the annual calculations used in this sheet we used a deterioration rate from MOVES for a 5-year-old vehicle, as emission rates increase as a vehicle ages. Argonne's VISION model, which uses National Highway Traffic Safety Administration data, shows that on average, both LDVs and HDVs reach the midpoint of its lifetime based on VMT at this age (vehicles are driven more miles per year earlier in their life). As there is limited data for AFV emission rates, we cannot use MOVES simulations to directly calculate them. For AFLEET 2013, we used the AirCRED methodology, by developing "AFV multipliers" for each pollutant based on EPA light-duty vehicle and heavy-duty engine certification tailpipe emission data. However for AFLEET 2016, we used the most recent GREET model (Argonne 2015). The 2015 version of GREET included a HDV module which has estimates of HDV air pollutant emissions for the first time in the history of the model (Cai et al. 2015).

Shifting from the use of conventional vehicles to AFVs can impact energy security and the environment. In order to better analyze the costs and benefits of AFVs, we included estimates of the externality costs (i.e. indirect damages) of these factors. As externality costs are not explicitly captured in the marketplace, society will consume and emit more than if the price had included the full social cost. We surveyed the literature to estimate the externality costs of petroleum use, GHG emissions, and air pollutant emissions.

For petroleum use, we used estimates of the Michalek et al. (2011) to estimate the risk of losses due to oil supply risk of losses due to oil supply disruptions, higher costs due to the effect of US demand on world oil prices, and the cost of existing policies meant to enhance oil security. For GHG emissions, we used social cost of carbon estimates from the Interagency Working Group on Social Cost of Carbon (2015). The estimates include changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services due to climate change. For air pollutant emissions we used the Air Pollution Emission Experiments and Policy Analysis (APEEP) model, which calculates the marginal damages corresponding to SO₂, VOC, NO_x, PM_{2.5}, PM₁₀, and NH₃ emissions (Muller and Mendelsohn 2006). From this model, we use the VOC, NO_x, PM_{2.5}, and PM₁₀ data. Currently, APEEP does not include CO, as studies examining the health benefits reduced emissions have not been able to quantify the incremental benefits for CO when other pollutants are reduced at the same time. Thus in AFLEET 2016, we do not include CO externality costs but will continue to monitor the research in this area for inclusion in the future.

2.4 Payback Outputs Sheet

This sheet summarizes the outputs of the Simple Payback Calculator with tables and graphs for costs, petroleum use, GHGs, and air pollutant emissions. In the cost, energy use and emissions, and externality cost tables (Figures 8-10), both LDVs and HDVs are included, while LDV and HDV simple payback, energy use and emissions, and externality costs are presented separately in the graphs (Figures 11-20). The simple payback graphs and externality cost tables and graphs are new to AFLEET 2016. The following figures are shown as an example of the outputs generated; a user's results will vary depending on the specific inputs used.

Figure 8. Payback Outputs Sheet – Annual Costs Summary Table

	Gasoline	Diesel	Gasoline HEV	Gasoline PHEV	Gasoline EREV	EV	G.H2 FCV	Diesel HEV	Diesel HHV	B20	B100	E85	LPG	CNG	LNG / Diesel LNG Pilot Ignition
Acquisition Cost															
Light-Duty (LD) Fleet & Infrastructure	\$1,000,000		\$1,150,000		\$1,700,000	\$1,500,000	\$2,925,000				\$1,125,000		\$1,300,000	\$1,350,000	
Heavy-Duty (HD) Fleet & Infrastructure		\$10,500,000				\$33,500,000			\$12,500,000		\$10,500,000			\$13,000,000	
Annual Operating Cost - Private Station Fueling															
LD Fleet & Infrastructure	\$149,239		\$128,902		\$118,410	\$112,476	\$153,246				\$194,020		\$162,875	\$132,515	
HD Fleet & Infrastructure		\$5,473,171				\$4,824,318			\$4,952,290		\$6,653,558			\$5,197,884	
Incremental Acquisition Cost - Private Station Fueling															
Compared to Gasoline LD Fleet			\$150,000		\$700,720	\$500,027	\$1,925,000				\$125,000		\$300,000	\$350,000	
Compared to Diesel HD Fleet						\$23,001,173			\$2,000,000		\$0			\$2,500,000	
Annual Operating Savings - Private Station Fueling															
Compared to Gasoline LD Fleet			\$20,337		\$30,829	\$36,763	-\$4,007				-\$44,781		-\$13,637	\$16,724	
Compared to Diesel HD Fleet						\$648,853			\$520,881		-\$1,180,387			\$275,287	
Simple Payback (years) - Private Station Fueling															
LD Passenger Car Fleet			7.4		22.7	13.6	No payback				No payback		No payback	20.9	
LD High Fuel Price Sensitivity			6.3		17.7	10.5	284.9				No payback		No payback	12.7	
LD Low Fuel Price Sensitivity			8.9		31.7	19.2	No payback				No payback		No payback	58.7	
HD Refuse Truck Fleet															
HD High Fuel Price Sensitivity						35.4			3.8		No payback			9.1	
HD Low Fuel Price Sensitivity						22.1			3.3		No payback			3.8	
						88.9			4.6		No payback			No payback	

Figure 9. Payback Outputs Sheet – Annual Energy Use and Emissions Summary Table

	Gasoline	Diesel	Gasoline HEV	Gasoline PHEV	Gasoline EREV	EV	G.H2 FCV	Diesel HEV	Diesel HHV	B20	B100	E85	LPG	CNG	LNG / Diesel LNG Pilot Ignition
Annual Life-Cycle Petroleum Use (barrels)															
LD Petroleum Use	449.4		321.0		93.6	6.1	2.9				17.1		150.5	2.4	
HD Petroleum Use		16,928.0				266.7			13,119.2		742.1			97.5	
Annual Life-Cycle Greenhouse Gas Emissions (short tons)															
LD GHG Emissions	253.3		181.0		144.5	145.0	170.2				56.2		222.9	225.4	
HD GHG Emissions		9,278.7				6,303.0			7,191.0		2,442.0			9,128.4	
Vehicle Operation Air Pollutant Emissions (lb)															
LD Passenger Car Fleet															
CO	2,424.6		1,816.3		518.0	0.0	0.0				3,248.1		2,532.4	1,754.8	
NOx	101.0		65.0		18.5	0.0	0.0				200.3		104.6	84.4	
PM10	33.3		33.3		28.3	26.2	26.2				30.5		33.3	33.3	
PM2.5	12.1		12.1		8.4	6.9	6.9				11.3		12.1	12.1	
VOC	129.8		99.4		28.3	0.0	0.0				62.3		145.0	73.0	
HD Refuse Truck Fleet															
CO		1,640.9				0.0			1,640.9		1,640.9			21,331.7	
NOx		4,232.0				0.0			4,232.0		4,232.0			2,962.4	
PM10		394.4				309.5			394.4		394.4			394.4	
PM2.5		161.1				80.0			161.1		161.1			161.1	
VOC		259.2				0.0			259.2		259.2			880.9	

Figure 10. Payback Outputs Sheet – Annual externality Costs Summary Table

	Gasoline	Diesel	HEV	PHEV	EREV	EV	G.H2 FCV	Diesel HEV	Diesel HHV	B20	B100	E85	LPG	CNG	LNG Pilot Ignition
Life-Cycle Petroleum Use Costs															
LD Petroleum Use	\$6,976		\$4,983		\$1,453	\$95	\$45				\$265		\$2,336	\$37	
HD Petroleum Use		\$262,752				\$4,140			\$203,633		\$11,519			\$1,514	
Life-Cycle GHG Emission Costs															
LD GHG Emissions	\$9,460		\$6,757		\$5,394	\$5,413	\$6,354				\$2,097		\$8,322	\$8,417	
HD GHG Emissions		\$346,470				\$235,358			\$268,514		\$91,183			\$340,858	
Vehicle Operation Air Pollutant Emission Costs															
LD Passenger Car Fleet															
CO	\$0		\$0		\$0	\$0	\$0				\$0		\$0	\$0	
NOx	\$7		\$4		\$1	\$0	\$0				\$13		\$7	\$6	
PM10	\$130		\$130		\$121	\$118	\$118				\$117		\$130	\$130	
PM2.5	\$665		\$665		\$460	\$379	\$379				\$623		\$665	\$665	
VOC	\$724		\$554		\$158	\$0	\$0				\$347		\$808	\$407	
Light-Duty Total	\$1,525		\$1,353		\$741	\$497	\$497				\$1,101		\$1,610	\$1,208	
HD Refuse Truck Fleet															
CO		\$0				\$0			\$0		\$0			\$0	
NOx		\$280				\$0			\$280		\$280			\$196	
PM10		\$1,424				\$1,402			\$1,424		\$1,424			\$1,424	
PM2.5		\$8,871				\$4,403			\$8,871		\$8,871			\$8,871	
VOC		\$1,445				\$0			\$1,445		\$1,445			\$4,912	
Heavy-Duty Total		\$12,021				\$5,804			\$12,021		\$12,021			\$15,404	
Total Petroleum, GHG, and Air Pollutant Costs															
LD Fleet	\$17,960		\$13,093		\$7,588	\$6,005	\$6,895				\$3,463		\$12,269	\$9,662	
HD Fleet		\$621,243				\$245,302			\$484,168		\$114,723			\$357,776	
Total Petroleum, GHG, and Air Pollutant Cost Savings															
LD Fleet			\$4,868		\$10,372	\$11,955	\$11,065				\$14,498		\$5,691	\$8,298	
HD Fleet						\$375,941			\$137,075		\$506,520			\$263,467	
Annual Operating Savings with externality Cost Savings															
Compared to Gasoline LD Fleet			\$25,205		\$41,201	\$48,719	\$7,058				-\$30,284		-\$7,945	\$25,022	
Compared to Diesel HD Fleet						\$1,024,794			\$657,956		-\$673,868			\$538,754	
Simple Payback with externality Costs (years)															
LD Passenger Car Fleet			6.0		17.0	10.3	272.7				No payback		No payback	14.0	
LD High Fuel Price Sensitivity			5.2		14.0	8.4	108.0				No payback		106.4	9.8	
LD Low Fuel Price Sensitivity			6.9		21.6	13.2	No payback				No payback		No payback	24.5	
HD Refuse Truck Fleet															
HD High Fuel Price Sensitivity						22.4			3.0		No payback			4.6	
HD Low Fuel Price Sensitivity						16.3			2.7		No payback			2.7	
						36.2			3.5		No payback			16.8	

Figure 11. Payback Outputs Sheet – LDV Simple Payback with and without Externalities Graph

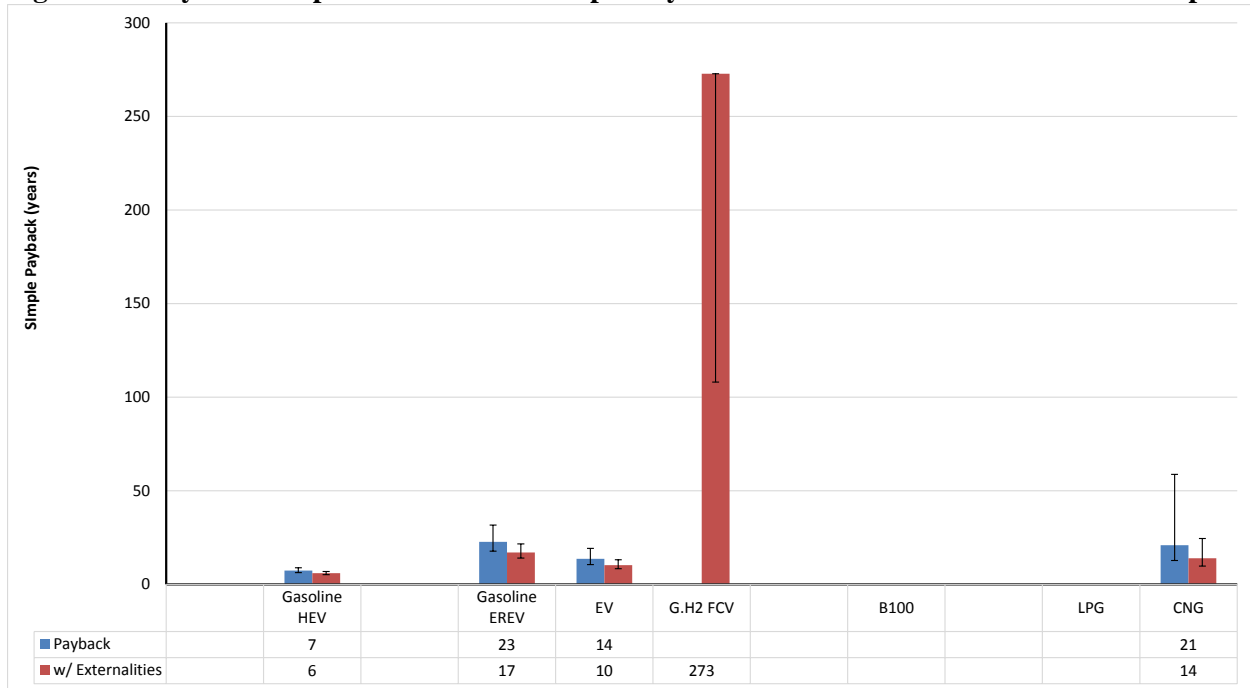


Figure 12. Payback Outputs Sheet – HDV Simple Payback with and without Externalities Graph

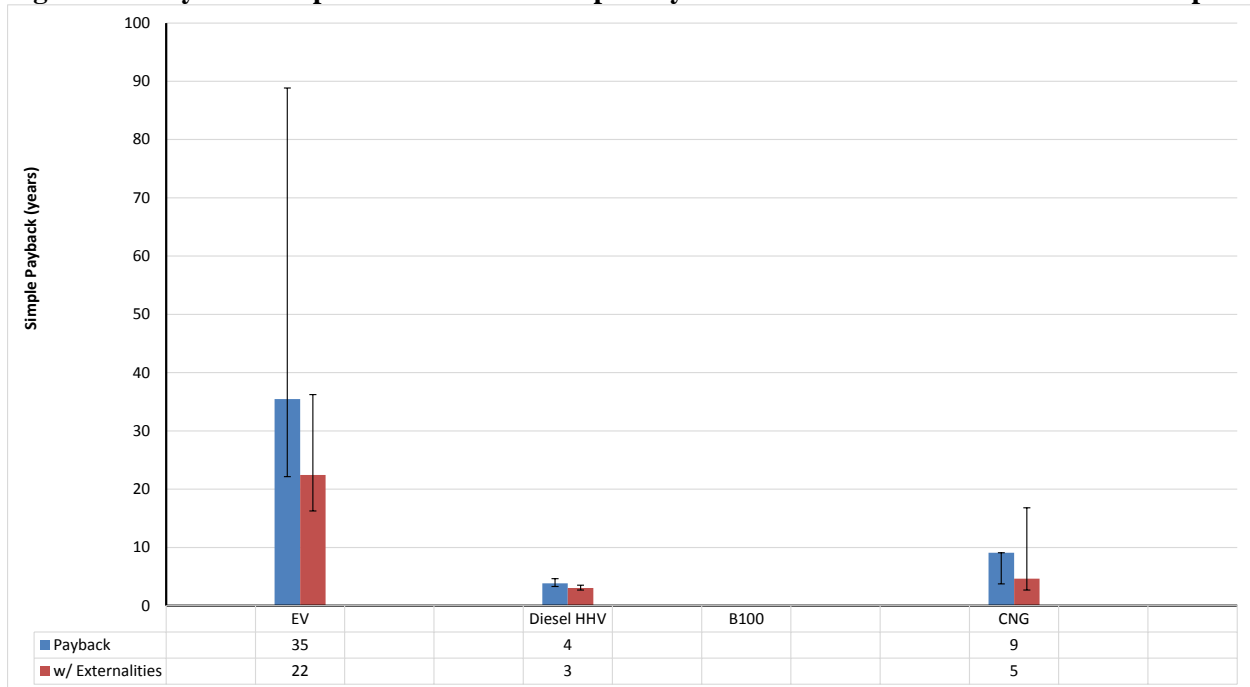


Figure 13. Payback Outputs Sheet – Annual LDV Energy Use and GHGs Summary Graph

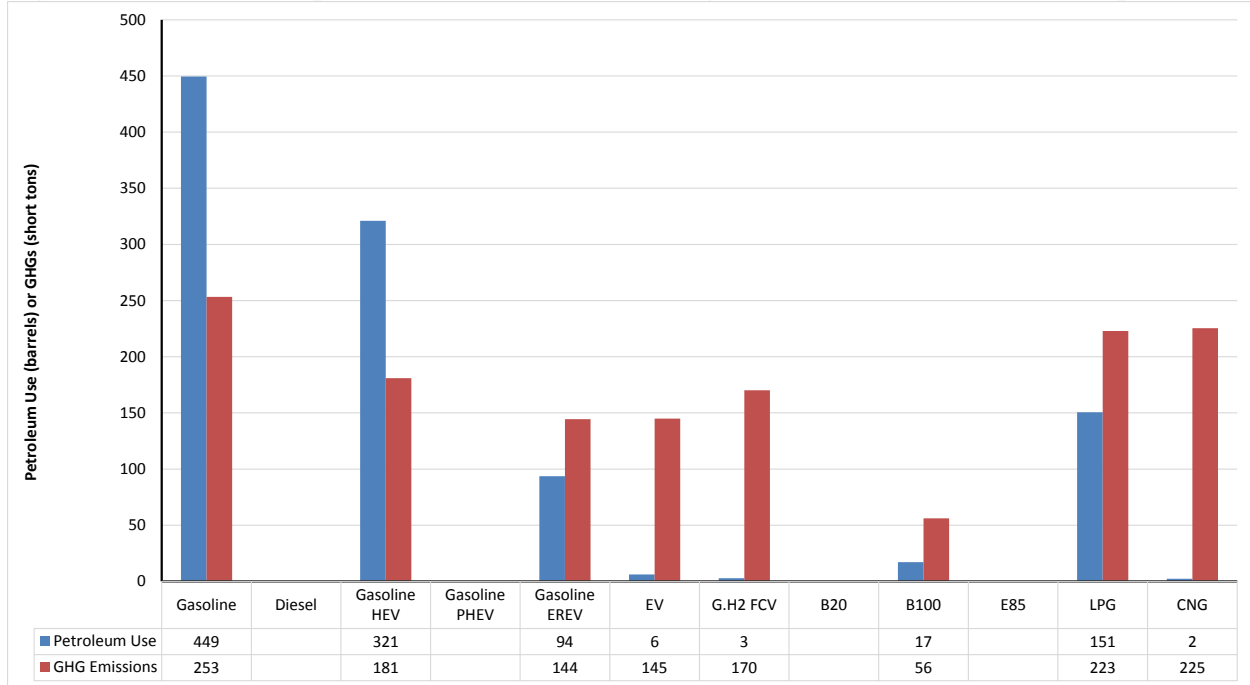


Figure 14. Payback Outputs Sheet – Annual HDV Energy Use and GHGs Summary Graph

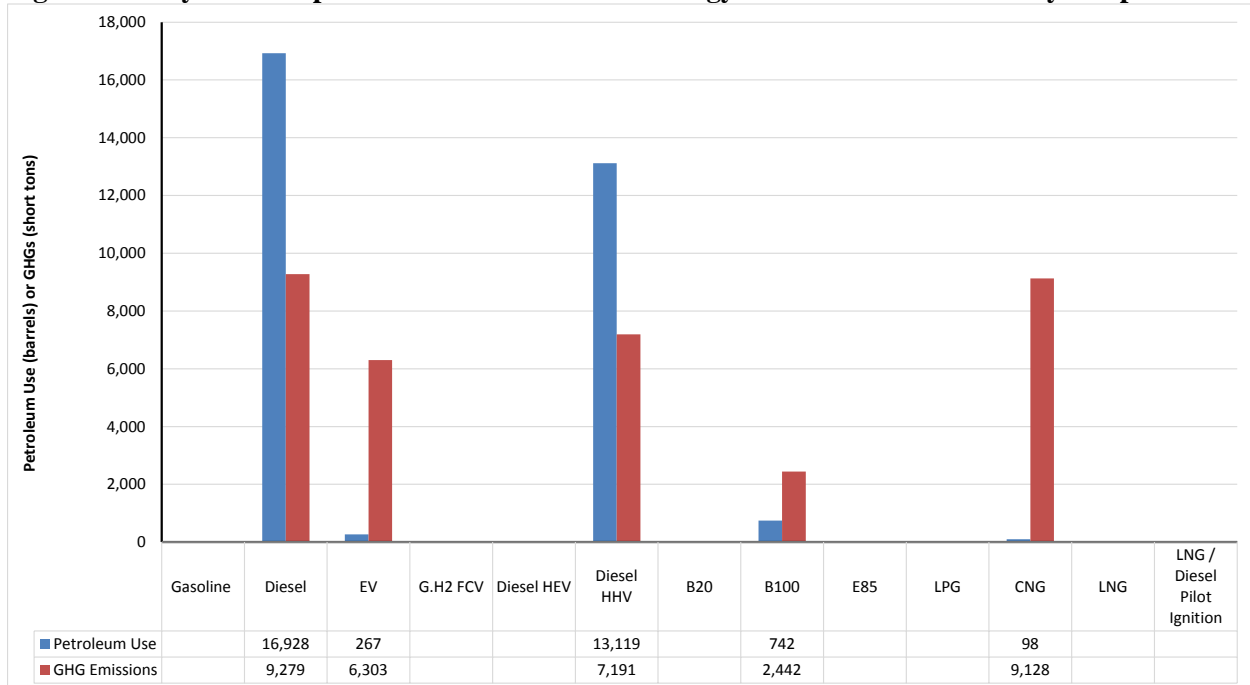


Figure 15. Payback Outputs Sheet – Annual LDV Air Pollutant Emissions Summary Graph

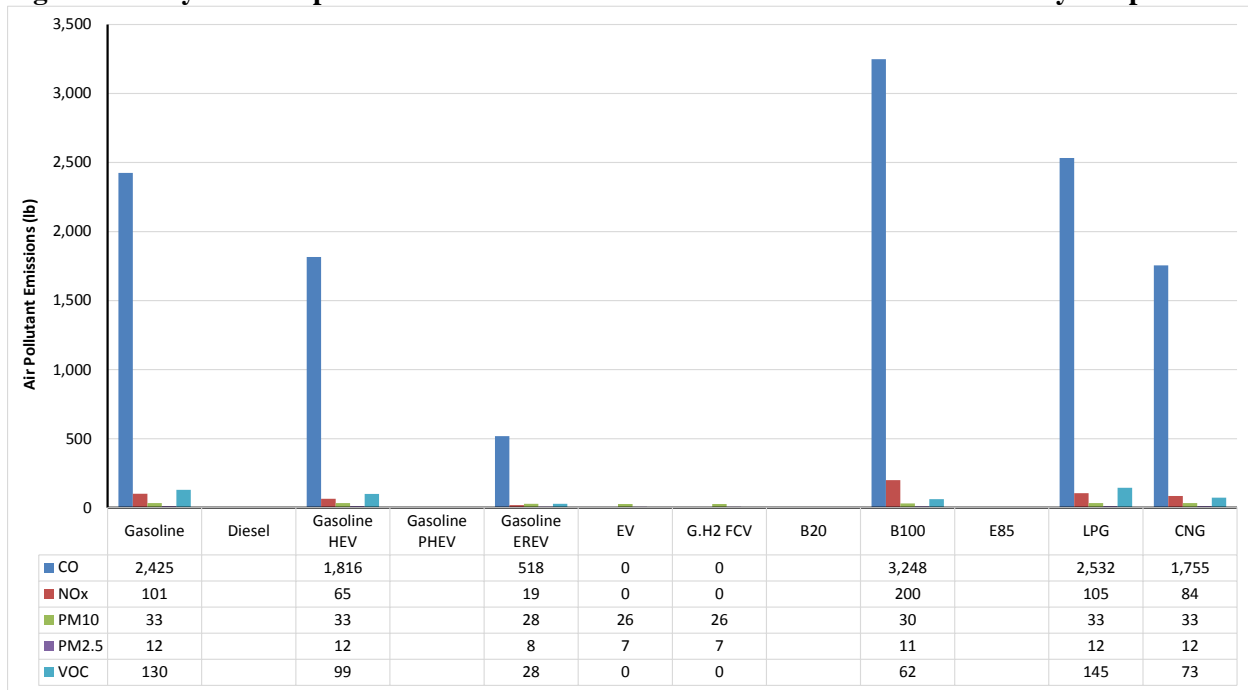


Figure 16. Payback Outputs Sheet – Annual HDV Air Pollutant Emissions Summary Graph

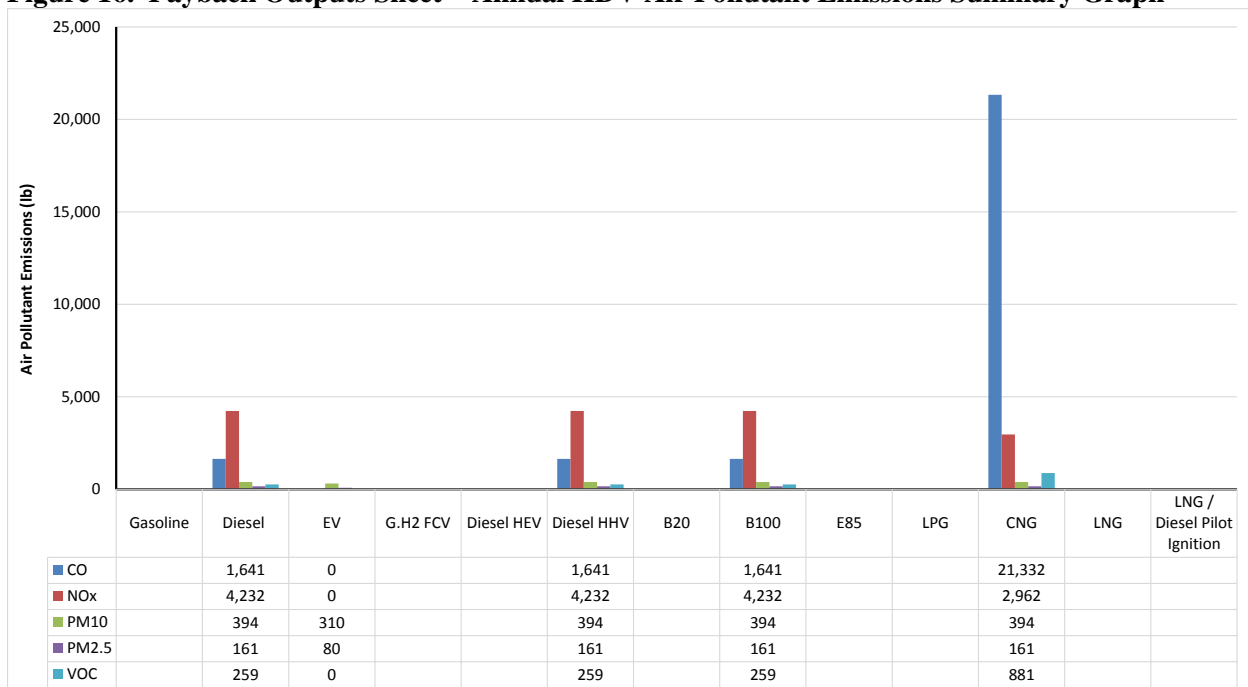


Figure 17. Payback Outputs Sheet – Annual LDV Annual Externality Costs Graph

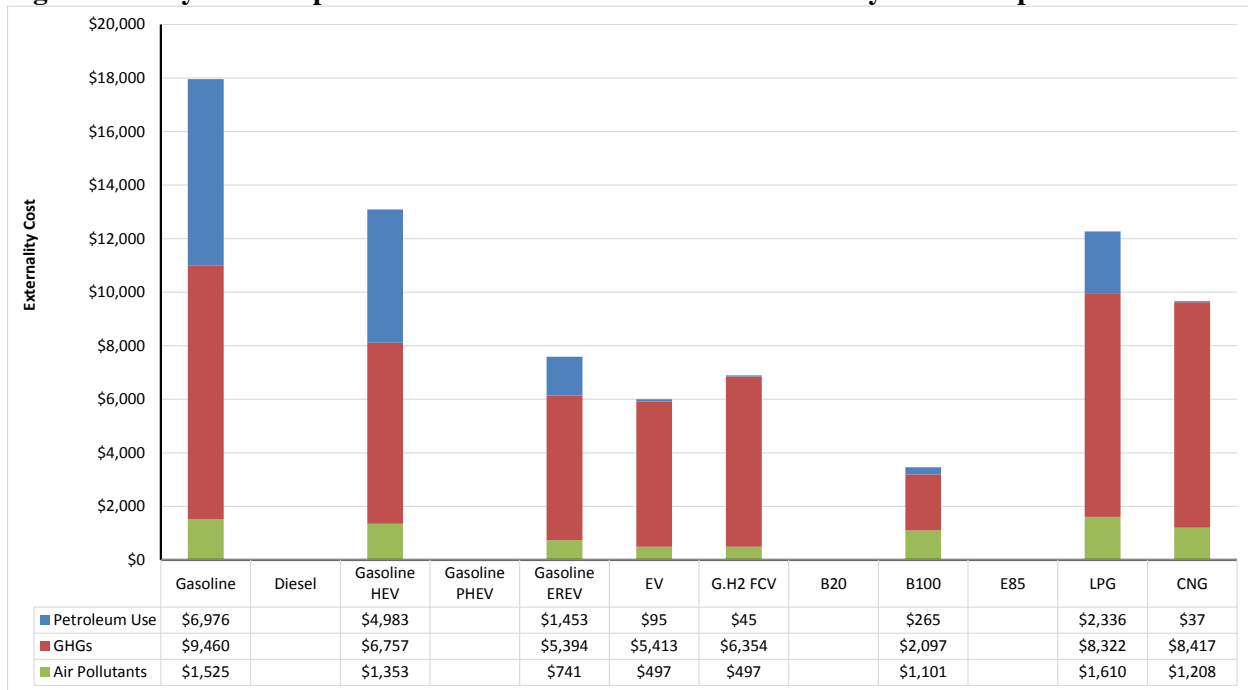


Figure 18. Payback Outputs Sheet – Annual HDV Annual Externality Costs Graph

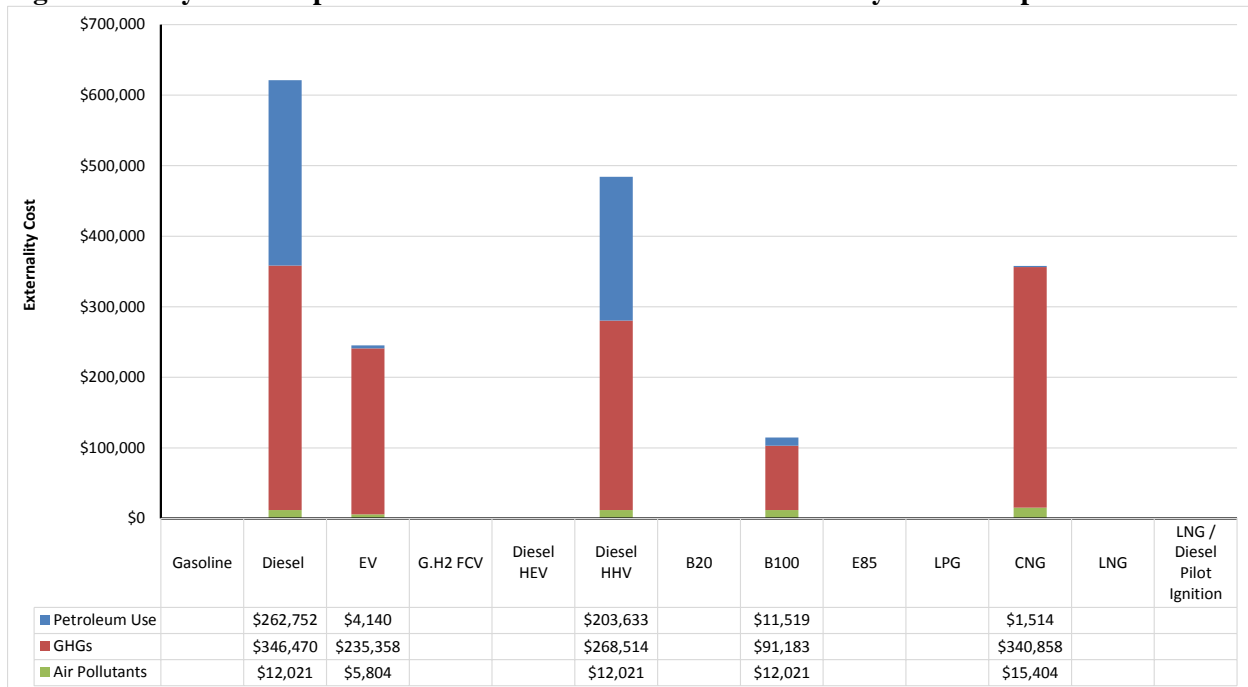
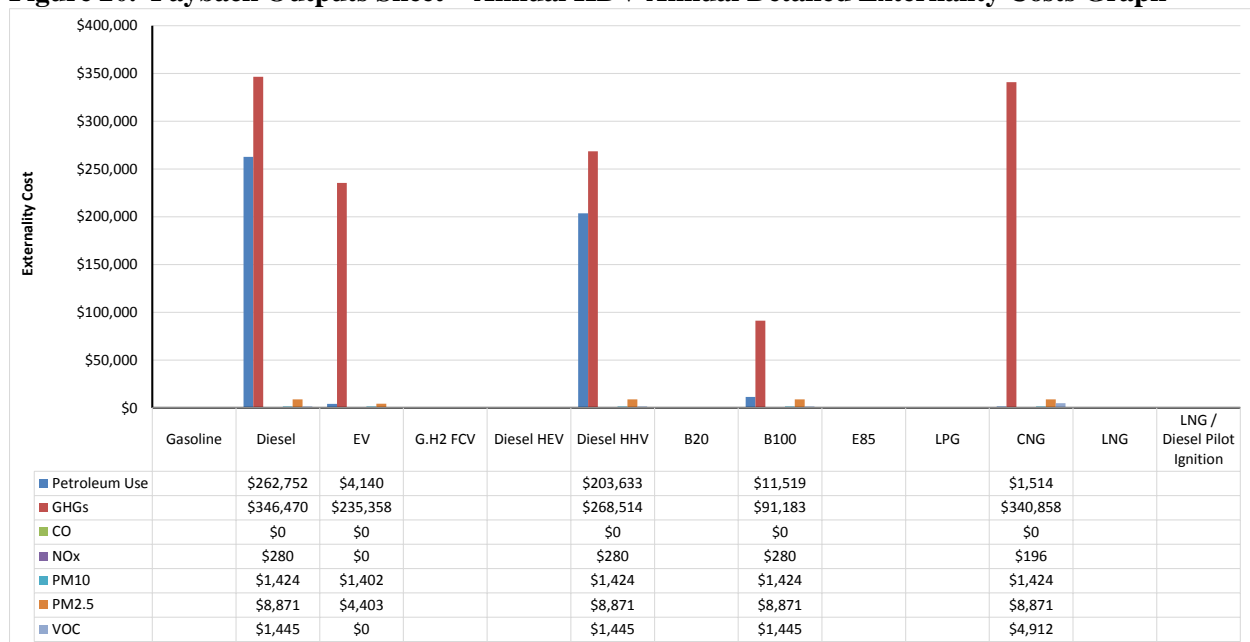


Figure 19. Payback Outputs Sheet – Annual LDV Annual Detailed Externality Costs Graph



Figure 20. Payback Outputs Sheet – Annual HDV Annual Detailed Externality Costs Graph



2.5 TCO Sheet

This sheet contains the Total Cost of Ownership Calculator, which evaluates the net present value of operating and fixed costs over the years of planned ownership of a new vehicle, as well as lifetime petroleum use, GHGs, air pollutant emissions, and externality costs. There are no key user inputs on the TCO sheet as all the data is based on user inputs from the Inputs and

Payback sheets. An advanced user may want to modify the mileage per year assumptions, as typically vehicles are driven more miles per year earlier in their life. This can be done by clicking the the blue hyperlink for “Annual Mileage” (Figures 21 and 23), which will take the user to the Background Data sheet to adjust mileage as a percentage of default value. The sheet includes both LDVs and HDVs; the user can use the hyperlinks at the top of the page as this sheet is very long.

The structure of the TCO calculations is to look at the operating and fixed costs on an annual basis for every year of planned ownership of a new vehicle and infrastructure purchase (Figures 21 and 23, several project year columns are not shown for clarity sake). This sheet has more detailed cost calculations as compared to the Simple Payback Calculator. It includes the costs of financing a loan, depreciation, insurance, license, and registration, in addition to the operating and acquisition costs. Using assumptions of inflation for various costs and a discount rate, a user can calculate the net present value of a vehicle purchase. In addition, lifetime petroleum use, GHGs, air pollutant emissions, and externality costs are also calculated (Figures 22 and 24). The difference in these calculations as compared to those on the Payback sheet is that these look at the actual air pollutant deterioration rate of a vehicle as it ages instead of using a deterioration rate for an average vehicle’s midpoint lifetime.

Figure 21. TCO Sheet – LDV Characteristics and Cost Calculations

Total Cost of Ownership Calculator

Project Year		1	2	3	4	5
Gasoline Passenger Car						
Gasoline Passenger Car Characteristics						
Number of Vehicles Purchased		50				
Annual Mileage	miles/vehicle	12,400	12,400	12,400	12,400	12,400
Fuel Economy	MPGGE	28.8	28.8	28.8	28.8	28.8
Fuel Usage	GGE/vehicle	431	431	431	431	431
Gasoline Passenger Car Acquisition Cost						
Total Purchase Price of Vehicle(s)	\$/fleet	\$1,000,000				
Total Vehicle Incentives	\$/fleet	\$0				
LD Infrastructure Cost	\$/fleet	\$0				
LD Infrastructure Incentives	\$/fleet	\$0				
Total Net Price of Vehicle(s) and Infra	\$/fleet	\$1,000,000				
Vehicle Down Payment	\$/fleet	\$0				
Vehicle Loan Amount	\$/fleet	\$1,000,000				
Infrastructure Down Payment	\$/fleet	\$0				
Infrastructure Loan Amount	\$/fleet	\$0				
Fixed Costs - Annual Gasoline Passenger Car Fleet Acquisition						
Vehicle Credit	\$/year	\$0				
Down Payment	\$/year	\$0				
Vehicle Interest Payment	\$/year	\$33,700	\$27,399	\$20,886	\$14,154	\$7,194
Vehicle Principal Payment	\$/year	\$186,967	\$193,267	\$199,780	\$206,513	\$213,473
Infrastructure Credit	\$/year	\$0				
Infrastructure Down Payment	\$/year	\$0				
Infrastructure Interest Payment	\$/year	\$0	\$0	\$0	\$0	\$0
Infrastructure Principal Payment	\$/year	\$0	\$0	\$0	\$0	\$0
Total Acquisition Costs	\$/year	\$220,667	\$220,667	\$220,667	\$220,667	\$220,667
Fixed Costs - Annual Gasoline Passenger Car Fleet Depreciation						
Vehicle Resale Value	\$/year	\$770,000	\$654,500	\$556,325	\$472,876	\$401,945
Vehicle Depreciation Cost	\$/year	\$230,000	\$115,500	\$98,175	\$83,449	\$70,931
Infrastructure Resale Value	\$/year	\$0	\$0	\$0	\$0	\$0
Infrastructure Depreciation Cost	\$/year	\$0	\$0	\$0	\$0	\$0
Total Depreciation Cost	\$/year	\$230,000	\$115,500	\$98,175	\$83,449	\$70,931
Fixed Costs - Annual Gasoline Passenger Car Fleet Insurance and Licensing						
Insurance	\$/year	\$49,650	\$50,842	\$52,062	\$53,311	\$54,591
License and Registration	\$/year	\$5,375	\$5,504	\$5,636	\$5,771	\$5,910
Total Insurance & Licensing Costs	\$/year	\$55,025	\$56,346	\$57,698	\$59,083	\$60,501
Operating Costs - Gasoline Passenger Car Fleet						
Fuel Cost	\$/year	\$61,139	\$62,473	\$63,836	\$65,229	\$66,653
	\$/mile	\$0.10	\$0.10	\$0.10	\$0.11	\$0.11
Diesel Exhaust Fluid Cost	\$/year	\$0	\$0	\$0	\$0	\$0
	\$/mile	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
Maintenance and Repair Cost	\$/year	\$88,100	\$90,214	\$92,379	\$94,597	\$96,867
	\$/mile	\$0.14	\$0.15	\$0.15	\$0.15	\$0.16
Miscellaneous Public/Private Station Costs	\$/year	\$0	\$0	\$0	\$0	\$0
	\$/mile	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
Total Operating Costs	\$/year	\$149,239	\$152,687	\$156,216	\$159,826	\$163,520
Annual Net Cash Flow	\$/year	-\$424,930	-\$429,700	-\$434,580	-\$439,575	-\$42,742
Discounted Cash Flow	\$/year	-\$424,930	-\$426,162	-\$427,455	-\$428,809	-\$41,352
Net Present Value (NPV)		-\$1,748,709				
Total Cost of Ownership Summary - Per Lifetime Ownership of Gasoline Passenger Car Fleet						
Financing	\$102,184	\$33,700	\$27,174	\$20,544	\$13,807	\$6,960
Depreciation	\$594,260	\$0	\$0	\$0	\$0	\$594,260
Fuel	\$314,004	\$61,139	\$61,959	\$62,790	\$63,632	\$64,485
Diesel Exhaust Fluid	\$0	\$0	\$0	\$0	\$0	\$0
Maintenance and Repair	\$454,433	\$88,100	\$89,472	\$90,865	\$92,280	\$93,717
Insurance	\$256,102	\$49,650	\$50,423	\$51,208	\$52,006	\$52,815
License and Registration	\$27,725	\$5,375	\$5,459	\$5,544	\$5,630	\$5,718
Total Cost of Ownership	\$1,748,709					

Figure 22. TCO Sheet – LDV Energy Use and Emissions and Externality Costs Calculations

Total Cost of Ownership Calculations		Project Year				
		1	2	3	4	5
Annual Gasoline Passenger Car Fleet Life-Cycle Petroleum Use, Life-Cycle Greenhouse Gas Emissions, and Vehicle Operation Air Pollutant Emissions						
Petroleum Use	barrels/year	449.4	449.4	449.4	449.4	449.4
GHG	short ton/year	253.3	253.3	253.3	253.3	253.3
CO	lb/year	1,366.8	1,332.9	1,339.1	2,407.7	2,424.6
NOx	lb/year	66.3	62.9	63.2	100.1	101.0
PM10	lb/year	5.5	5.5	5.5	7.0	7.1
PM10 (TBW)	lb/year	26.1	26.2	26.2	26.2	26.2
PM2.5	lb/year	4.0	4.1	4.1	5.2	5.2
PM2.5 (TBW)	lb/year	6.8	6.9	6.9	6.9	6.9
VOC	lb/year	57.3	57.6	58.6	92.4	94.2
VOC (Evap)	lb/year	35.5	35.5	35.5	35.5	35.5
Annual Gasoline Passenger Car Fleet Life-Cycle Petroleum Use, Life-Cycle Greenhouse Gas Emission, and Vehicle Operation Air Pollutant Emission Externality Costs						
Petroleum Use	\$/year	\$6,976	\$7,143	\$7,315	\$7,490	\$7,670
GHG	\$/year	\$9,460	\$9,687	\$9,919	\$10,157	\$10,401
CO	\$/year	\$0	\$0	\$0	\$0	\$0
NOx	\$/year	\$4	\$4	\$4	\$7	\$7
PM10	\$/year	\$33	\$34	\$35	\$46	\$48
PM10 (TBW)	\$/year	\$159	\$164	\$168	\$172	\$176
PM2.5	\$/year	\$222	\$229	\$235	\$306	\$315
PM2.5 (TBW)	\$/year	\$376	\$388	\$397	\$406	\$416
VOC	\$/year	\$319	\$329	\$342	\$553	\$578
VOC (Evap)	\$/year	\$198	\$203	\$208	\$213	\$218
Total Petroleum Use, GHG Emissions, and Vehicle Operation Emissions and Externality Costs - Per Lifetime Ownership of Gasoline Passenger Car Fleet						
Petroleum Use	barrels	2,247	\$36,593			
GHG	short tons	1,267	\$49,623			
CO	pounds	8,871	\$0			
NOx	pounds	394	\$28			
PM10	pounds	162	\$1,037			
PM2.5	pounds	57	\$3,291			
VOC	pounds	538	\$3,161			

Figure 23. TCO Sheet – HDV Characteristics and Cost Calculations

Total Cost of Ownership Calculator

	Project Year	1	2	3	4	5
Diesel Refuse Truck						
Diesel Refuse Truck Characteristics						
Number of Vehicles Purchased		50				
Annual Mileage	miles/vehicle	23,400	23,400	23,400	23,400	23,400
Fuel Economy	MPGGE	1.5	1.5	1.5	1.5	1.5
Fuel Usage	GGE/vehicle	15,600	15,600	15,600	15,600	15,600
Diesel Refuse Truck Acquisition Cost						
Total Purchase Price of Vehicle(s)	\$/fleet	\$10,500,000				
Total Vehicle Incentives	\$/fleet	\$0				
LD Infrastructure Cost	\$/fleet	\$0				
LD Infrastructure Incentives	\$/fleet	\$0				
Total Net Price of Vehicle(s) and Infra	\$/fleet	\$10,500,000				
Vehicle Down Payment	\$/fleet	\$0				
Vehicle Loan Amount	\$/fleet	\$10,500,000				
Infrastructure Down Payment	\$/fleet	\$0				
Infrastructure Loan Amount	\$/fleet	\$0				
Fixed Costs - Annual Diesel Refuse Truck Fleet Acquisition						
Vehicle Credit	\$/year	\$0				
Down Payment	\$/year	\$0				
Vehicle Interest Payment	\$/year	\$353,850	\$287,692	\$219,304	\$148,612	\$75,537
Vehicle Principal Payment	\$/year	\$1,963,149	\$2,029,307	\$2,097,695	\$2,168,387	\$2,241,462
Infrastructure Credit	\$/year	\$0				
Infrastructure Down Payment	\$/year	\$0				
Infrastructure Interest Payment	\$/year	\$0	\$0	\$0	\$0	\$0
Infrastructure Principal Payment	\$/year	\$0	\$0	\$0	\$0	\$0
Total Acquisition Costs	\$/year	\$2,316,999	\$2,316,999	\$2,316,999	\$2,316,999	\$2,316,999
Fixed Costs - Annual Diesel Refuse Truck Fleet Depreciation						
Vehicle Resale Value	\$/year	\$8,085,000	\$6,872,250	\$5,841,413	\$4,965,201	\$4,220,421
Vehicle Depreciation Cost	\$/year	\$2,415,000	\$1,212,750	\$1,030,838	\$876,212	\$744,780
Infrastructure Resale Value	\$/year	\$0	\$0	\$0	\$0	\$0
Infrastructure Depreciation Cost	\$/year	\$0	\$0	\$0	\$0	\$0
Total Depreciation Cost	\$/year	\$2,415,000	\$1,212,750	\$1,030,838	\$876,212	\$744,780
Fixed Costs - Annual Diesel Refuse Truck Fleet Insurance and Licensing						
Insurance	\$/year	\$256,350	\$262,502	\$268,802	\$275,254	\$281,860
License and Registration	\$/year	\$27,000	\$27,648	\$28,312	\$28,991	\$29,687
Total Insurance & Licensing Costs	\$/year	\$283,350	\$290,150	\$297,114	\$304,245	\$311,547
Operating Costs - Diesel Refuse Truck Fleet						
Fuel Cost	\$/year	\$2,047,746	\$2,100,659	\$2,154,940	\$2,210,624	\$2,267,747
	\$/mile	\$1.75	\$1.80	\$1.84	\$1.89	\$1.94
Diesel Exhaust Fluid Cost	\$/year	\$43,680	\$44,645	\$45,632	\$46,640	\$47,671
	\$/mile	\$0.04	\$0.04	\$0.04	\$0.04	\$0.04
Maintenance and Repair Cost	\$/year	\$3,381,746	\$3,462,907	\$3,546,017	\$3,631,122	\$3,718,269
	\$/mile	\$2.89	\$2.96	\$3.03	\$3.10	\$3.18
Miscellaneous Public/Private Station Costs	\$/year	\$0	\$0	\$0	\$0	\$0
	\$/mile	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
Total Operating Costs	\$/year	\$5,473,171	\$5,608,212	\$5,746,589	\$5,888,386	\$6,033,686
Annual Net Cash Flow	\$/year	-\$8,073,520	-\$8,215,361	-\$8,360,702	-\$8,509,630	-\$4,441,811
Discounted Cash Flow	\$/year	-\$8,073,520	-\$8,147,735	-\$8,223,624	-\$8,301,209	-\$4,297,353
Net Present Value (NPV)		-\$37,043,441				
Total Cost of Ownership Summary - Per Lifetime Ownership of Diesel Refuse Truck Fleet						
Financing	\$1,072,935	\$353,850	\$285,324	\$215,709	\$144,972	\$73,081
Depreciation	\$6,239,734	\$0	\$0	\$0	\$0	\$6,239,734
Fuel	\$10,601,196	\$2,047,746	\$2,083,367	\$2,119,609	\$2,156,481	\$2,193,994
Diesel Exhaust Fluid	\$224,460	\$43,680	\$44,278	\$44,884	\$45,498	\$46,120
Maintenance and Repair	\$17,443,555	\$3,381,746	\$3,434,402	\$3,487,878	\$3,542,187	\$3,597,342
Insurance	\$1,322,292	\$256,350	\$260,342	\$264,395	\$268,512	\$272,693
License and Registration	\$139,270	\$27,000	\$27,420	\$27,847	\$28,281	\$28,721
Total Cost of Ownership	\$37,043,441					

Figure 24. TCO Sheet – HDV Energy Use and Emissions Calculations

Total Cost of Ownership Calculus		Project Year	1	2	3	4	5
Annual Diesel Refuse Truck Fleet Life-Cycle Petroleum Use, Life-Cycle Greenhouse Gas Emissions, and Vehicle Operation Air Pollutant Emissions							
Petroleum Use	barrels/year		16,928.0	16,928.0	16,928.0	16,928.0	16,928.0
GHG	short ton/year		9,278.7	9,278.7	9,278.7	9,278.7	9,278.7
CO	lb/year		1,274.0	1,305.2	1,349.4	1,578.3	1,640.9
NOx	lb/year		2,842.6	2,846.1	2,851.0	4,225.0	4,232.0
PM10	lb/year		55.9	55.9	55.9	84.9	84.9
PM10 (TBW)	lb/year		309.5	309.5	309.5	309.5	309.5
PM2.5	lb/year		53.5	53.5	53.5	81.2	81.2
PM2.5 (TBW)	lb/year		80.0	80.0	80.0	80.0	80.0
VOC	lb/year		237.1	237.7	238.6	257.9	259.2
VOC (Evap)	lb/year		0.0	0.0	0.0	0.0	0.0

Annual Diesel Refuse Truck Fleet Life-Cycle Petroleum Use, Life-Cycle Greenhouse Gas Emission, and Vehicle Operation Air Pollutant Emission Externality Costs							
Petroleum Use	\$/year		\$262,752	\$269,058	\$275,515	\$282,128	\$288,899
GHG	\$/year		\$346,470	\$354,785	\$363,300	\$372,019	\$380,948
CO	\$/year		\$0	\$0	\$0	\$0	\$0
NOx	\$/year		\$188	\$193	\$198	\$301	\$308
PM10	\$/year		\$342	\$350	\$358	\$556	\$570
PM10 (TBW)	\$/year		\$1,890	\$1,935	\$1,982	\$2,029	\$2,078
PM2.5	\$/year		\$2,946	\$3,017	\$3,089	\$4,798	\$4,913
PM2.5 (TBW)	\$/year		\$4,403	\$4,508	\$4,617	\$4,727	\$4,841
VOC	\$/year		\$1,322	\$1,357	\$1,395	\$1,544	\$1,589
VOC (Evap)	\$/year		\$0	\$0	\$0	\$0	\$0

Total Petroleum Use, GHG Emissions, and Vehicle Operation Emissions and Externality Costs - Per Lifetime Ownership of Diesel Refuse Truck Fleet			
Petroleum Use	barrels	84,640	\$1,378,352
GHG	short tons	46,393	\$1,817,522
CO	pounds	7,148	\$0
NOx	pounds	16,997	\$1,188
PM10	pounds	1,885	\$12,089
PM2.5	pounds	723	\$41,859
VOC	pounds	1,230	\$7,207

2.6 TCO Outputs Sheet

This sheet summarizes the outputs of the Total Cost of Ownership Calculator with tables and graphs for costs, petroleum use, GHGs, and air pollutant emissions. In the cost, energy use and emissions, and externalities tables (Figures 25-27), both LDVs and HDVs are included, while LDVs and HDVs are presented separately in the graphs (Figures 28-43). This sheet has additional cost graphs as compared to the Payback Outputs sheet. Specifically, the cumulative cost of ownership compared to a conventional counterpart (Figures 28-29) show similar results to a simple payback. The payback period is equal to the year when the line for each AFV crosses the x-axis. Figures 30-31 show the cumulative cash flow for both AFVs and conventional vehicles. Figures 32-33 show the total cost of ownership broken down into the major cost categories: financing, depreciation, fuel, maintenance and repair, insurance, and license and registration. Figures 34-35 show the total cost of ownership but also include externality costs. The following figures are shown as an example of the outputs generated; a user's results will vary depending on the specific inputs used.

Figure 25. TCO Outputs Sheet – Lifetime Costs Summary Table

	Gasoline	Diesel	Gasoline HEV	Gasoline PHEV	Gasoline EREV	EV	G.H2 FCV	Diesel HEV	Diesel HHV	B20	B100	E85	LPG	CNG	LNG	LNG / Diesel Pilot Ignition
Light-Duty Passenger Car Fleet and Infrastructure																
Financing	\$102,184		\$117,512		\$173,713	\$153,276	\$298,889				\$114,957		\$132,840	\$137,949		
Depreciation	\$817,574		\$940,210		\$1,390,362	\$1,226,379	\$2,391,403				\$919,771		\$1,062,846	\$1,103,725		
Fuel	\$649,636		\$464,026		\$375,042	\$628,176	\$804,483				\$803,363		\$796,953	\$472,525		
Diesel Exhaust Fluid	\$0		\$0		\$0	\$0	\$0				\$10,688		\$0	\$0		
Maintenance and Repair	\$945,364		\$821,422		\$897,446	\$832,997	\$832,997				\$1,274,465		\$945,364	\$945,364		
Insurance	\$532,774		\$532,774		\$532,774	\$532,774	\$532,774				\$532,774		\$532,774	\$532,774		
License and Registration	\$57,677		\$57,677		\$57,677	\$57,677	\$57,677				\$57,677		\$57,677	\$57,677		
Total Cost of Ownership	\$3,105,209		\$2,933,620		\$3,427,014	\$3,431,279	\$4,918,223				\$3,713,694		\$3,528,453	\$3,250,013		
Heavy-Duty Refuse Truck Fleet and Infrastructure																
Financing	\$1,072,935					\$3,423,173			\$1,277,304		\$1,072,935			\$1,328,396		
Depreciation	\$8,584,525					\$27,389,516			\$10,219,673		\$8,584,525			\$10,628,460		
Fuel	\$22,157,108					\$16,470,132			\$18,241,779		\$34,929,186			\$19,134,852		
Diesel Exhaust Fluid	\$464,704					\$0			\$360,145		\$464,704			\$0		
Maintenance and Repair	\$36,288,112					\$35,509,715			\$35,748,256		\$36,288,112			\$36,476,433		
Insurance	\$2,750,786					\$2,750,786			\$2,750,786		\$2,750,786			\$2,750,786		
License and Registration	\$289,726					\$289,726			\$289,726		\$289,726			\$289,726		
Total Cost of Ownership	\$71,607,894					\$85,833,048			\$68,887,668		\$84,379,972			\$70,608,652		

Figure 26. TCO Outputs Sheet – Lifetime Energy Use and Emissions Summary Table

	Gasoline	Diesel	Gasoline HEV	Gasoline PHEV	Gasoline EREV	EV	G.H2 FCV	Diesel HEV	Diesel HHV	B20	B100	E85	LPG	CNG	LNG	LNG / Diesel Pilot Ignition
Lifetime Life-Cycle Petroleum Use (barrels)																
LD Petroleum Use	4,494		3,210		936	102	29				171		1,505	24		
HD Petroleum Use		169,280				2,667			131,192		7,421			975		
Lifetime Life-Cycle Greenhouse Gas Emissions (short tons)																
LD GHG Emissions	2,533		1,810		1,445	2,404	1,702				562		2,229	2,254		
HD GHG Emissions		92,787				63,030			71,910		24,420			91,284		
Lifetime Vehicle Operation Air Pollutant Emissions (lb)																
Light-Duty Passenger Car Fleet																
CO	25,032		18,752		5,348	0	0				34,052		26,144	18,117		
NOx	1,147		739		211	0	0				2,175		1,189	959		
PM10	343		343		285	262	262				310		343	343		
PM2.5	128		128		86	69	69				119		128	128		
VOC	1,475		1,113		317	0	0				715		1,668	834		
Heavy-Duty Refuse Truck Fleet																
CO		16,619				0			16,619		16,619			216,046		
NOx		38,345				0			38,345		38,345			38,345		
PM10		3,858				3,095			3,858		3,858			3,858		
PM2.5		1,529				800			1,529		1,529			1,529		
VOC		2,552				0			2,552		2,552			8,682		

Figure 27. TCO Outputs Sheet – Lifetime externality Costs Summary Table

	Gasoline	Diesel	Gasoline HEV	Gasoline PHEV	Gasoline EREV	EV	G.H2 FCV	Diesel HEV	Diesel HHV	B20	B100	E85	LPG	CNG	LNG	LNG / Diesel Pilot Ignition
Lifetime Life-Cycle Petroleum Use Costs																
LD Petroleum Use	\$77,794		\$55,567		\$16,202	\$1,761	\$503				\$2,955		\$26,056	\$417		
HD Petroleum Use		\$2,930,239				\$46,172			\$2,270,935		\$128,459			\$16,879		
Lifetime Life-Cycle Greenhouse Gas Emission Costs																
LD GHG Emissions	\$105,494		\$75,353		\$60,160	\$100,108	\$70,856				\$23,388		\$92,813	\$93,871		
HD GHG Emissions		\$3,863,869				\$2,624,733			\$2,994,499		\$1,016,888			\$3,801,288		
Lifetime Vehicle Operation Air Pollutant Emission Costs																
Light-Duty Passenger Car Fleet																
CO	\$0		\$0		\$0	\$0	\$0				\$0		\$0	\$0		
NOx	\$87		\$56		\$16	\$0	\$0				\$163		\$90	\$73		
PM10	\$2,343		\$2,343		\$1,945	\$1,786	\$1,786				\$2,119		\$2,343	\$2,343		
PM2.5	\$7,916		\$7,916		\$5,273	\$4,219	\$4,219				\$7,354		\$7,916	\$7,916		
VOC	\$9,364		\$7,055		\$2,012	\$0	\$0				\$4,543		\$10,616	\$5,301		
Light-Duty Total	\$19,710		\$17,370		\$9,246	\$6,005	\$6,005				\$14,180		\$20,964	\$15,632		
Heavy-Duty Refuse Truck Fleet																
CO		\$0				\$0			\$0		\$0			\$0		
NOx		\$2,859				\$0			\$2,859		\$2,859			\$2,001		
PM10		\$26,315				\$21,075			\$26,315		\$26,315			\$26,315		
PM2.5		\$94,292				\$49,100			\$94,292		\$94,292			\$94,292		
VOC		\$15,918				\$0			\$15,918		\$15,918			\$54,139		
Heavy-Duty Total		\$139,384				\$70,175			\$139,384		\$139,384			\$176,748		
Lifetime Total Petroleum, GHG, and Air Pollutant Costs																
LD Fleet	\$202,997		\$148,289		\$85,608	\$107,874	\$77,364				\$40,522		\$139,833	\$109,920		
HD Fleet		\$6,933,492				\$2,741,081			\$5,404,818		\$1,284,731			\$3,994,915		
Light-Duty Passenger Car Fleet and Infrastructure TCO with Externalities																
Financing	\$102,184		\$117,512		\$173,713	\$153,276	\$298,889				\$114,957		\$132,840	\$137,949		
Depreciation	\$817,574		\$940,210		\$1,390,362	\$1,226,379	\$2,391,403				\$919,771		\$1,062,846	\$1,103,725		
Fuel	\$649,636		\$464,026		\$375,042	\$628,176	\$804,483				\$803,363		\$796,953	\$472,525		
Diesel Exhaust Fluid	\$0		\$0		\$0	\$0	\$0				\$10,688		\$0	\$0		
Maintenance and Repair	\$945,364		\$821,422		\$897,446	\$832,997	\$832,997				\$1,274,465		\$945,364	\$945,364		
Insurance	\$532,774		\$532,774		\$532,774	\$532,774	\$532,774				\$532,774		\$532,774	\$532,774		
License and Registration	\$57,677		\$57,677		\$57,677	\$57,677	\$57,677				\$57,677		\$57,677	\$57,677		
Externalities	\$202,997		\$148,289		\$85,608	\$107,874	\$77,364				\$40,522		\$139,833	\$109,920		
TCO with Externalities	\$3,308,206		\$3,081,909		\$3,512,622	\$3,539,153	\$4,995,587				\$3,754,217		\$3,668,286	\$3,359,933		
Heavy-Duty Refuse Truck Fleet and Infrastructure TCO with Externalities																
Financing	\$1,072,935					\$3,423,173			\$1,277,304		\$1,072,935			\$1,328,396		
Depreciation	\$8,584,525					\$27,389,516			\$10,219,673		\$8,584,525			\$10,628,460		
Fuel	\$22,157,108					\$16,470,132			\$18,241,779		\$34,929,186			\$19,134,852		
Diesel Exhaust Fluid	\$464,704					\$0			\$360,145		\$464,704			\$0		
Maintenance and Repair	\$36,288,112					\$35,509,715			\$35,748,256		\$36,288,112			\$36,476,433		
Insurance	\$2,750,786					\$2,750,786			\$2,750,786		\$2,750,786			\$2,750,786		
License and Registration	\$289,726					\$289,726			\$289,726		\$289,726			\$289,726		
Externalities	\$6,933,492					\$2,741,081			\$5,404,818		\$1,284,731			\$3,994,915		
TCO with Externalities	\$78,541,387					\$88,574,129			\$74,292,486		\$85,664,703			\$74,603,567		

Figure 28. TCO Outputs Sheet – LDV Cumulative Cash Flow Compared to Gasoline Summary Graph

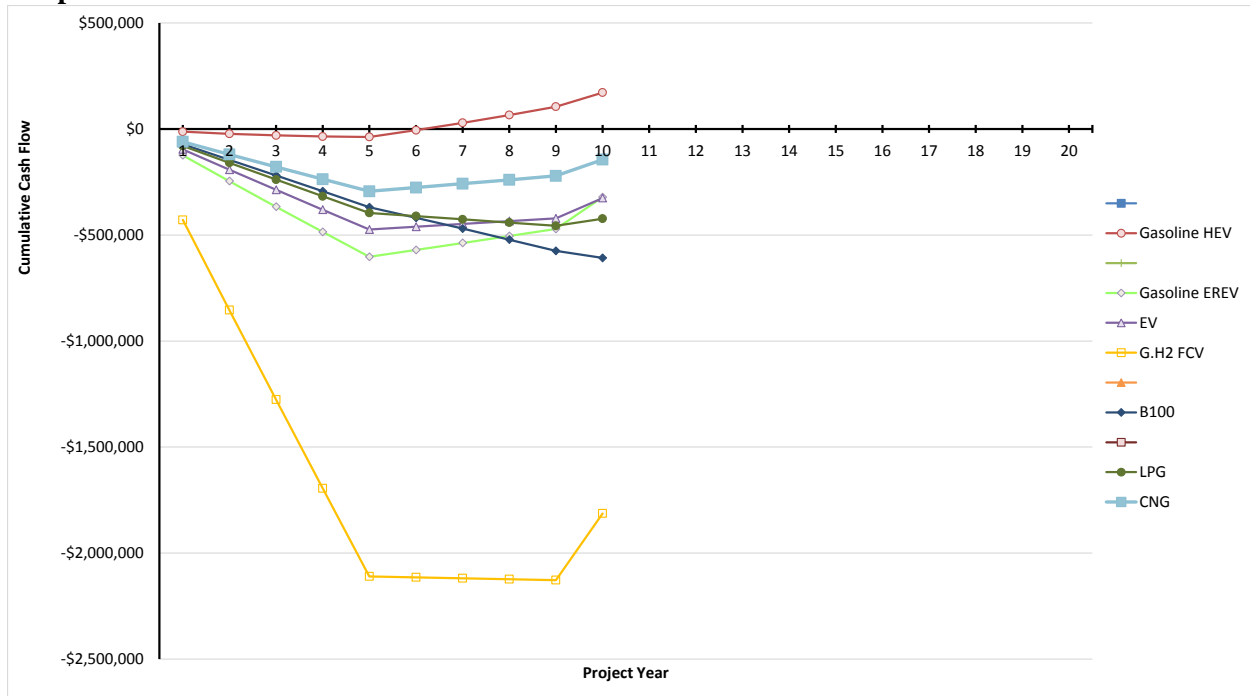


Figure 29. TCO Outputs Sheet – HDV Cumulative Cash Flow Compared to Diesel Summary Graph

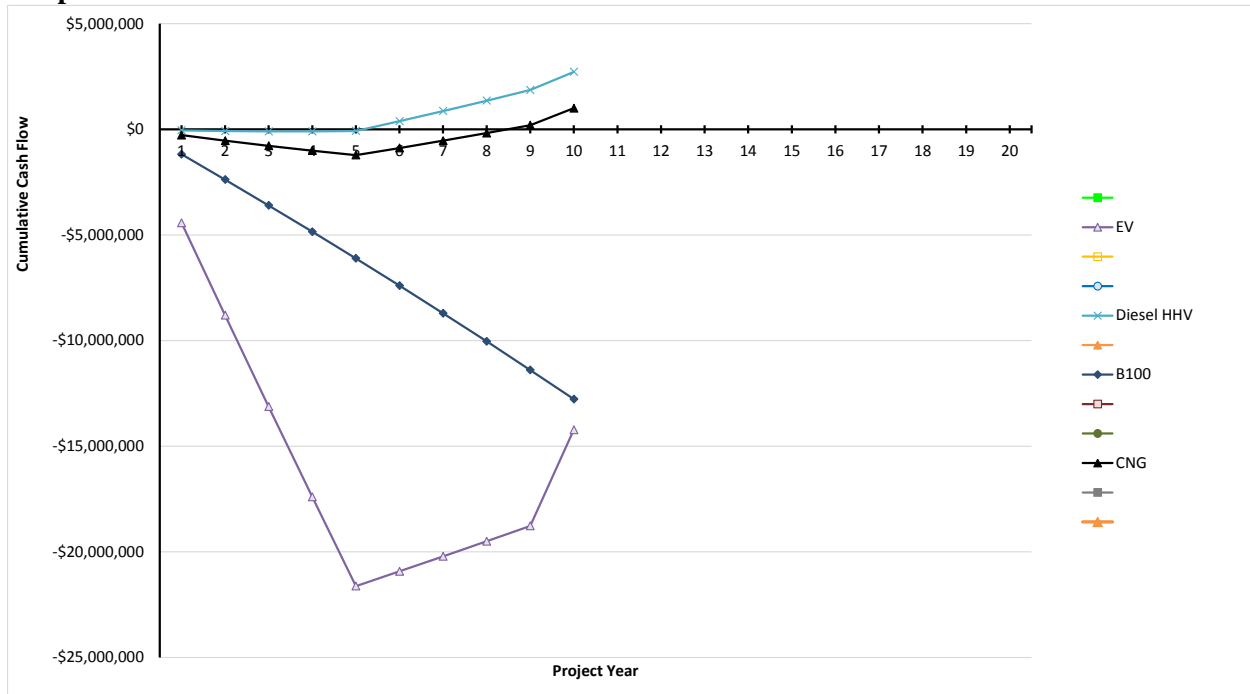


Figure 30. TCO Outputs Sheet – LDV Cumulative Cash Flow Summary Graph

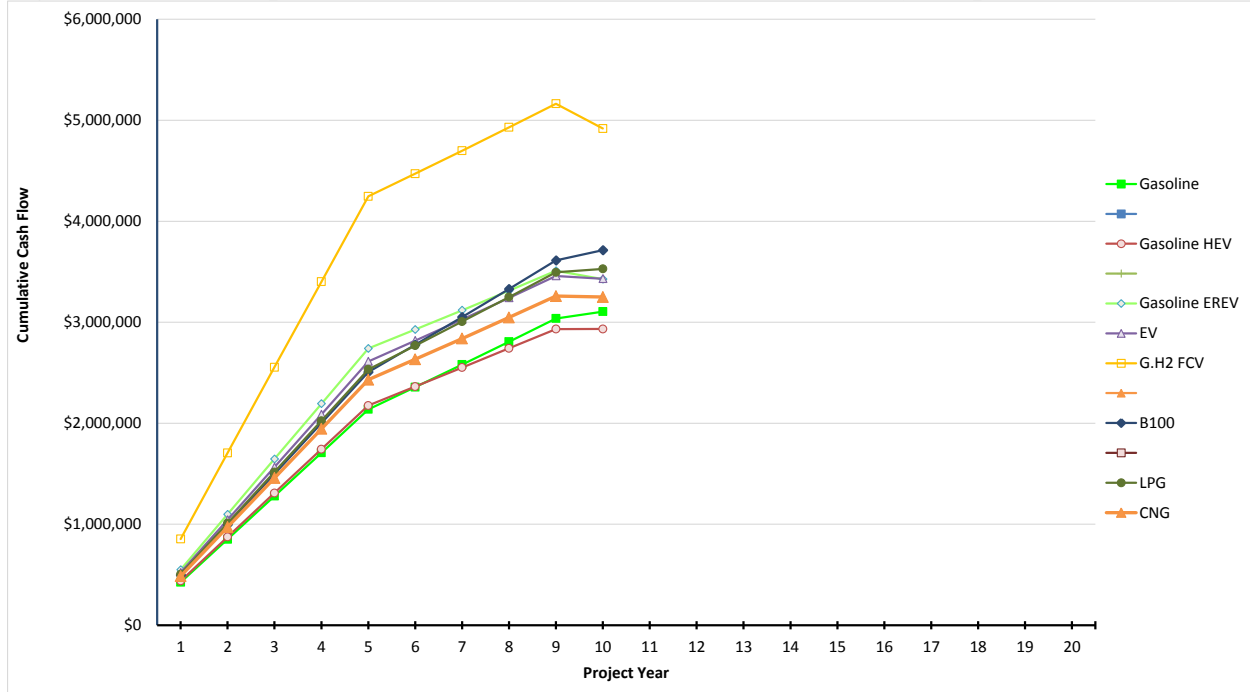


Figure 31. TCO Outputs Sheet – HDV Cumulative Cash Flow Summary Graph

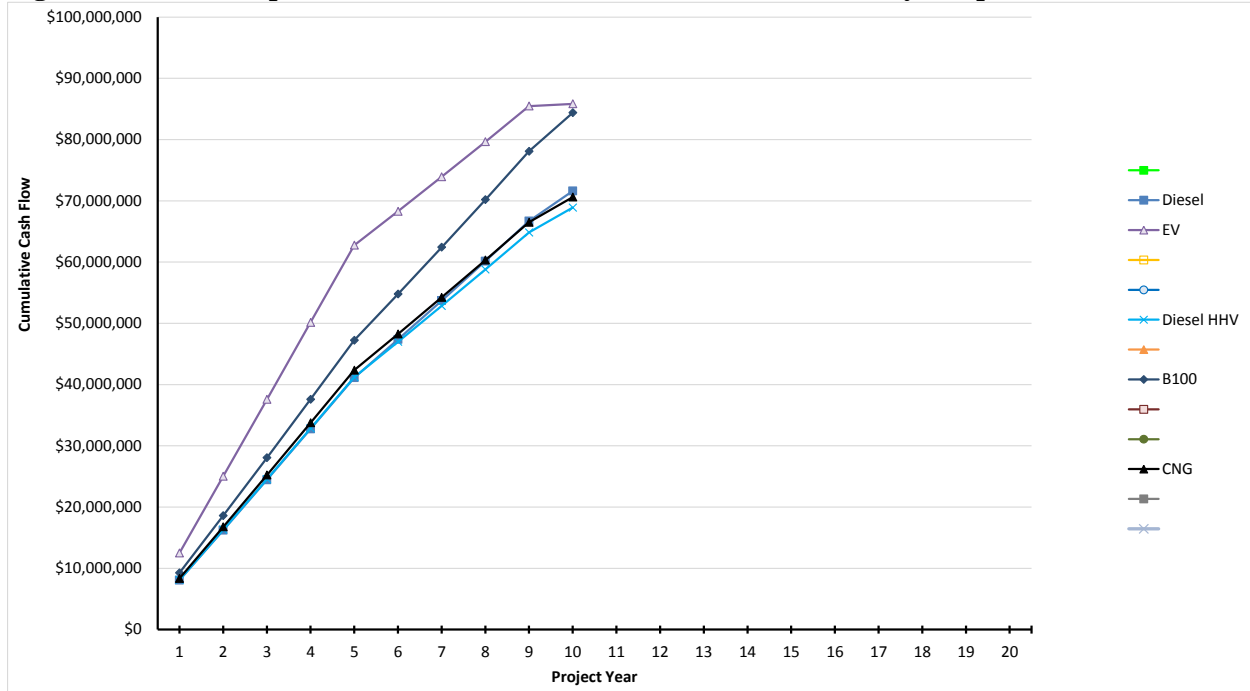


Figure 32. TCO Outputs Sheet – LDV Total Cost of Ownership Summary Graph

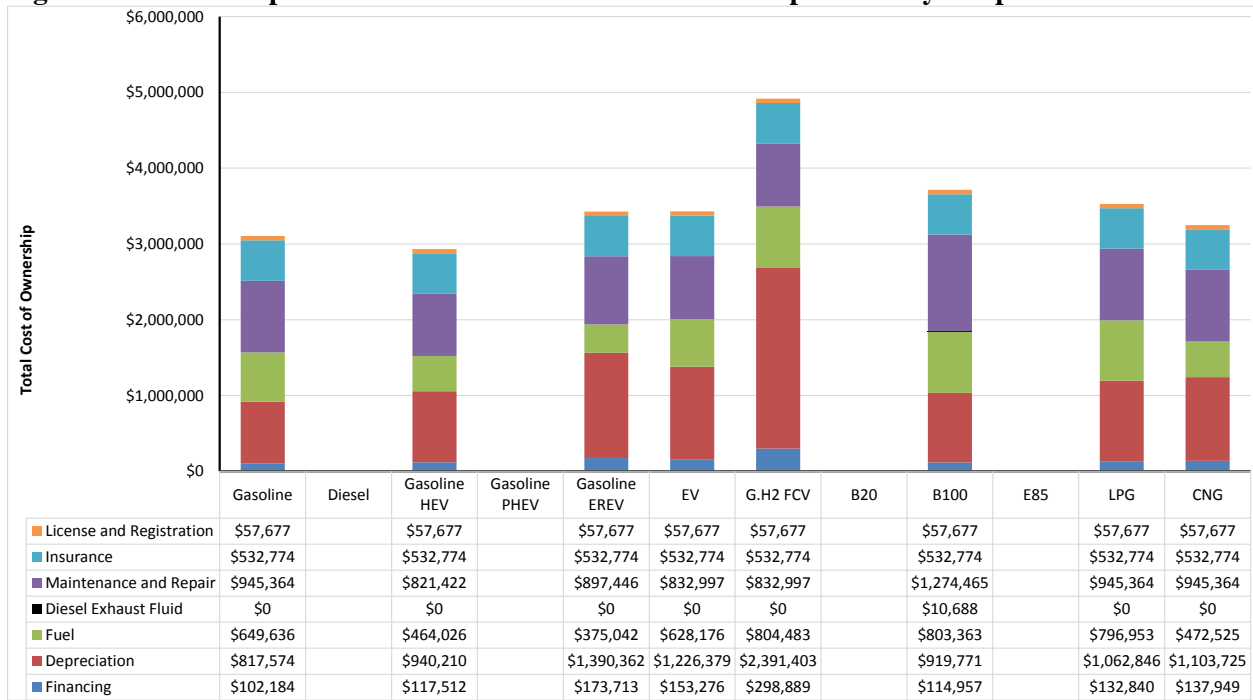


Figure 33. TCO Outputs Sheet – HDV Total Cost of Ownership Summary Graph

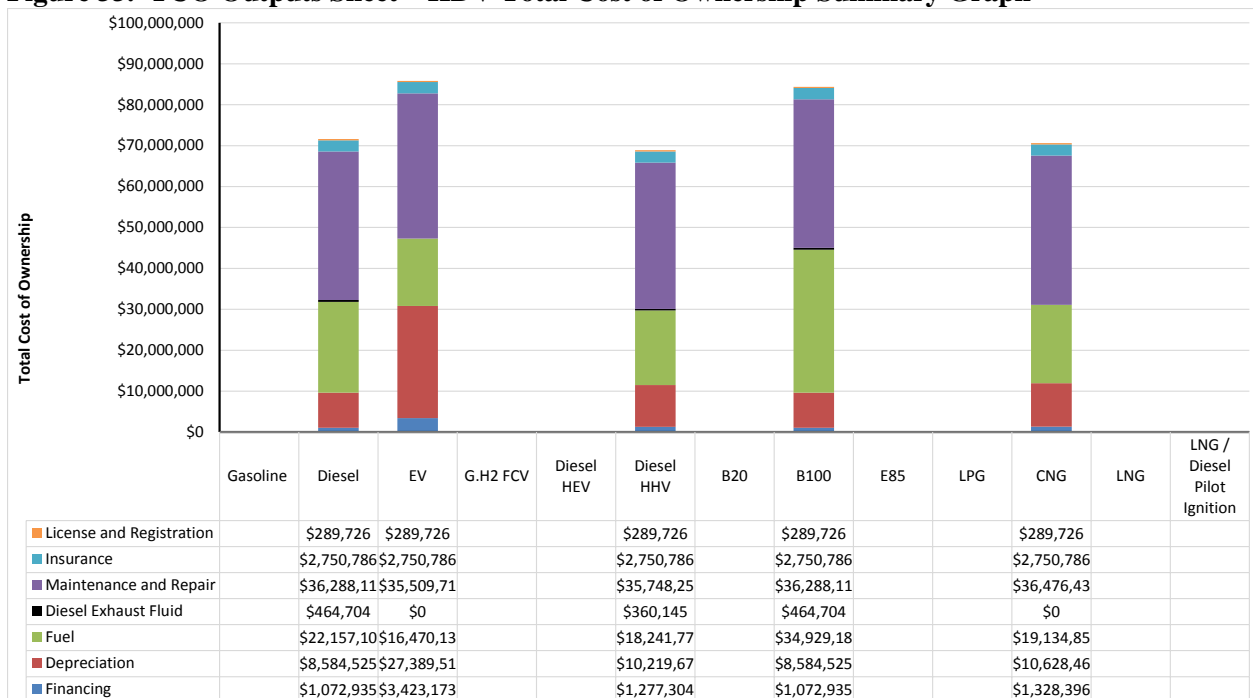


Figure 34. TCO Outputs Sheet – LDV Total Cost of Ownership w/ Externalities Summary Graph

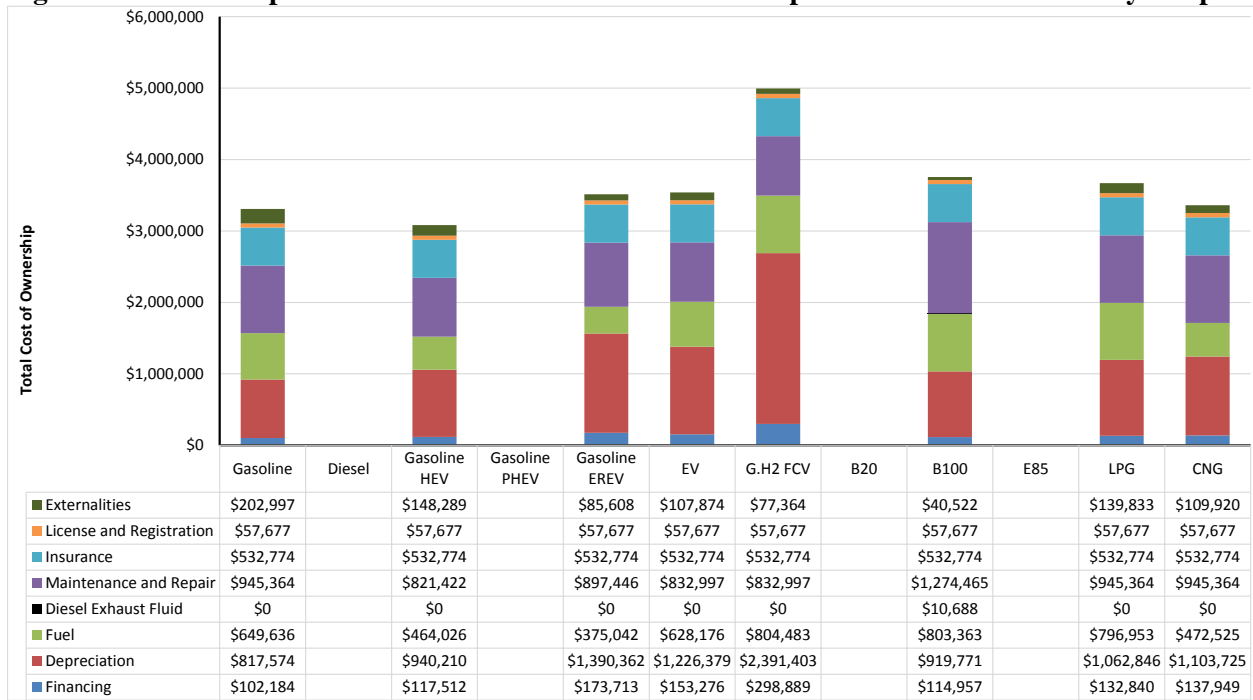


Figure 35. TCO Outputs Sheet – HDV Total Cost of Ownership w/ Externalities Summary Graph

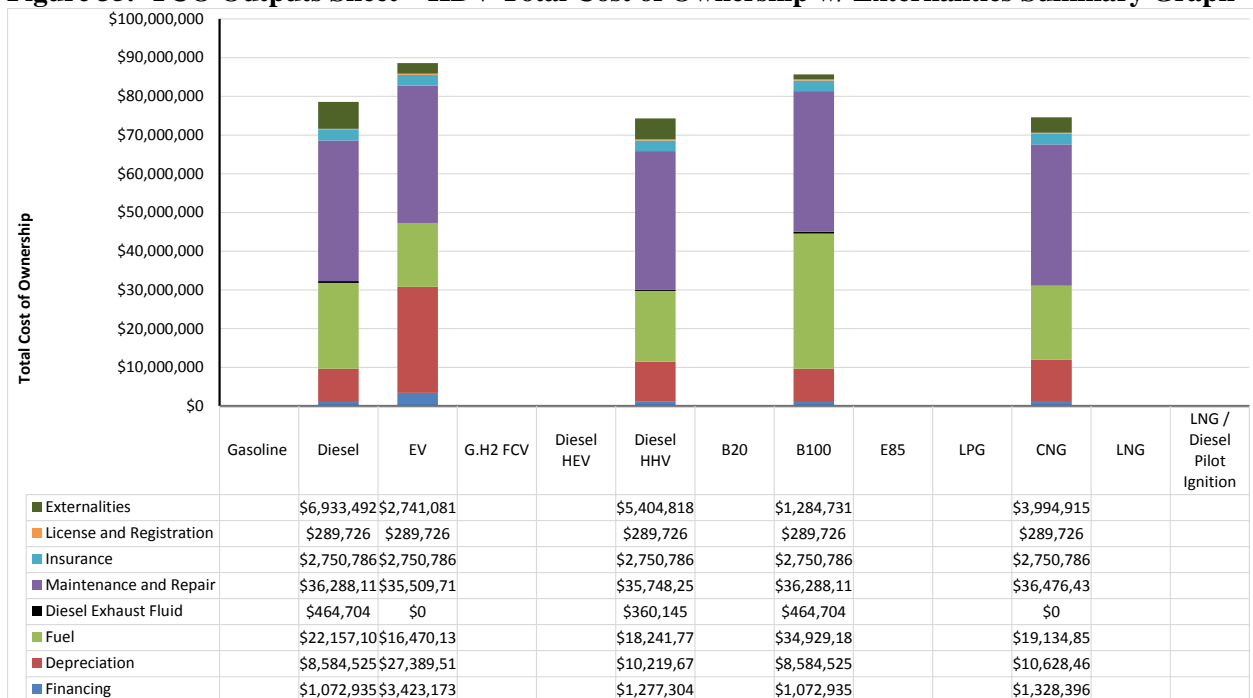


Figure 36. TCO Outputs Sheet – Lifetime LDV Energy Use and GHGs Summary Graph

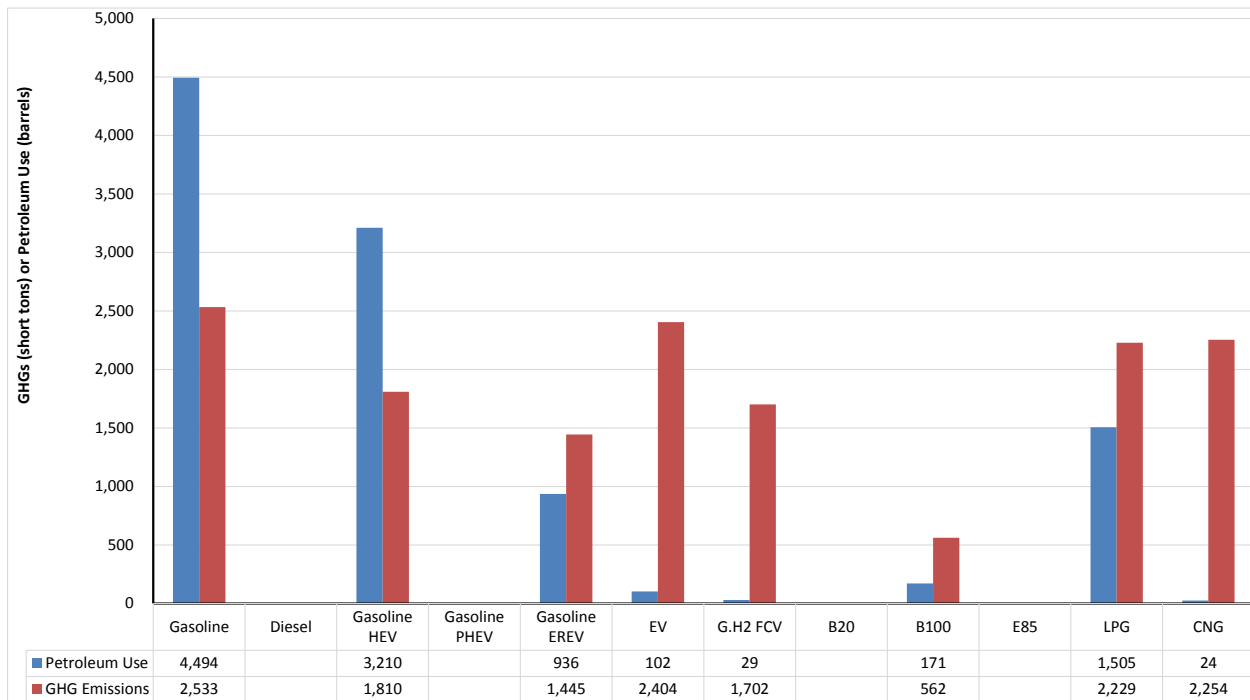


Figure 37. TCO Outputs Sheet – Lifetime HDV Energy Use and GHGs Summary Graph

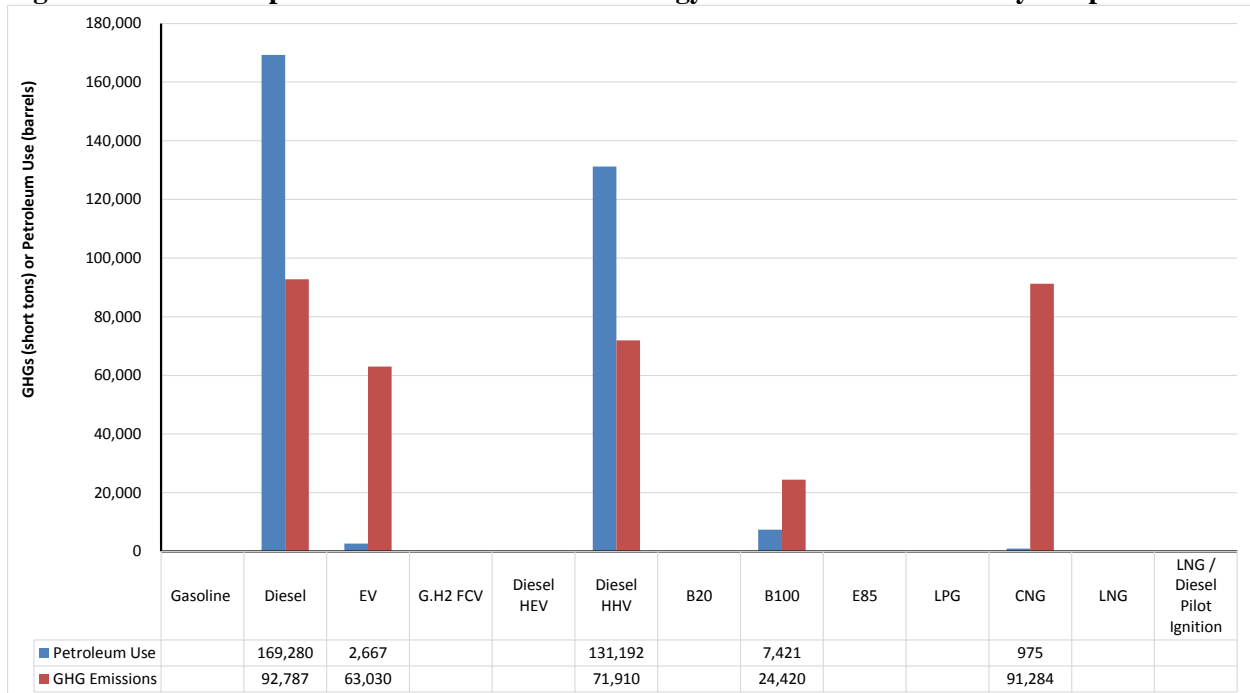


Figure 38. TCO Outputs Sheet – Lifetime LDV Air Pollutant Emissions Summary Graph

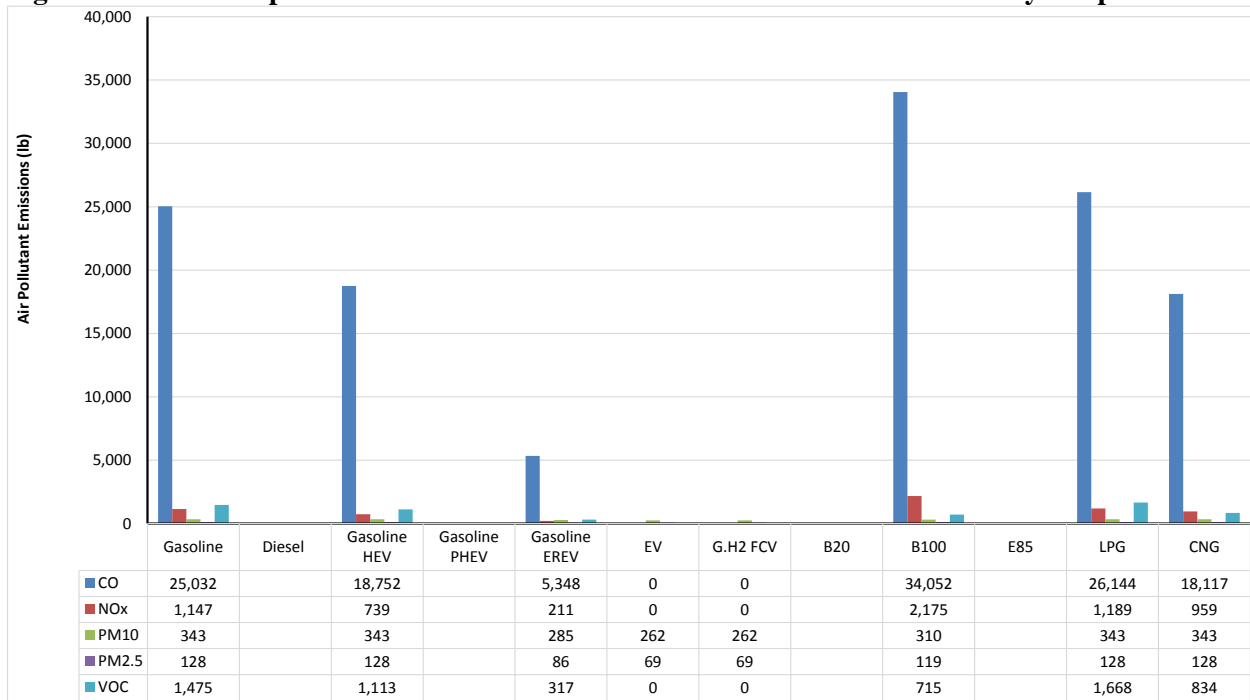


Figure 39. TCO Outputs Sheet – Lifetime HDV Air Pollutant Emissions Summary Graph

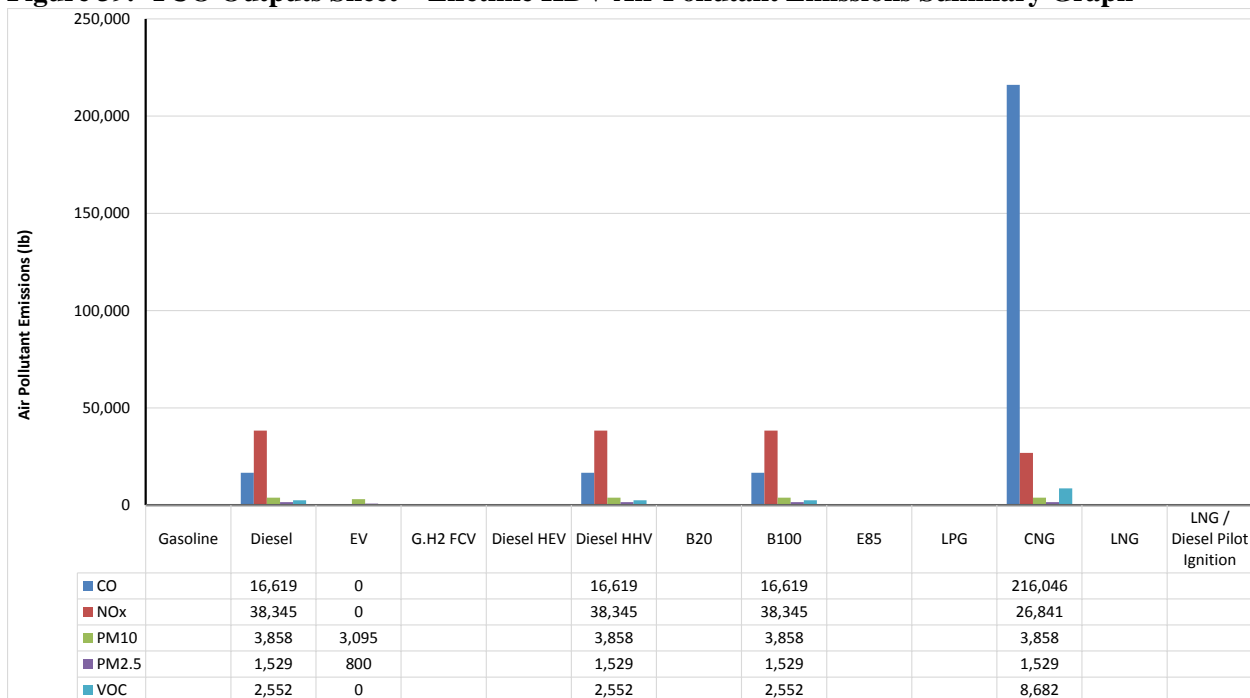


Figure 40. TCO Outputs Sheet – Lifetime LDV Externality Costs Summary Graph



Figure 41. TCO Outputs Sheet – Lifetime HDV Externality Costs Summary Graph

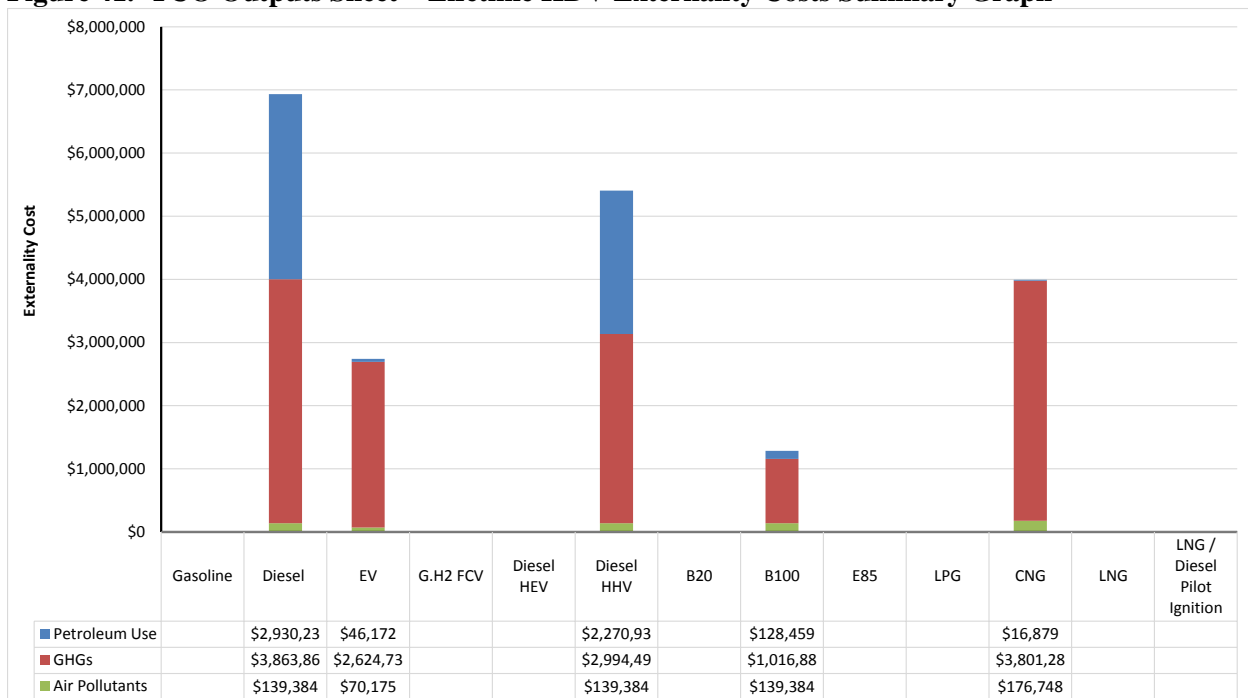
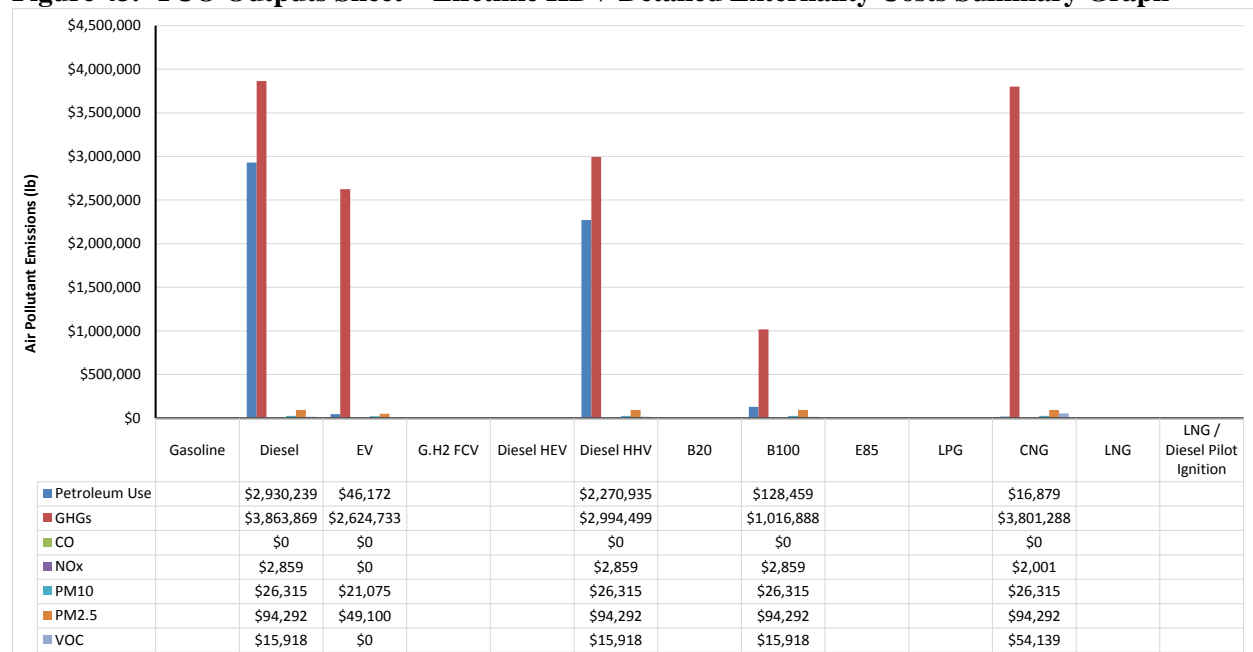


Figure 42. TCO Outputs Sheet – Lifetime LDV Detailed Externality Costs Summary Graph



Figure 43. TCO Outputs Sheet – Lifetime HDV Detailed Externality Costs Summary Graph



2.7 Footprint Sheet

This sheet contains the Fleet Energy and Emissions Footprint Calculator, which estimates the annual petroleum use, GHGs, air pollutant emissions, and externality costs of existing and

new vehicles, taking into consideration that older vehicles typically have higher air pollutant emission rates than newer ones. The key inputs (Figure 44) for this sheet are:

- **vehicle type**
- **model year**
- **annual vehicle mileage**
- **fuel use.**

The user can change the vehicle types via dropdown box. The user then must enter a model year between 1985 and 2020, vehicle mileage, and fuel use to estimate its energy use, emissions, and externality costs (Figure 45) of existing fleet vehicles and vehicles planned to be purchased. If one would like to examine more vehicles, the user can copy and paste the entire row(s) with calculations (rows 6-95 in AFLEET Tool 2016) below the existing rows.

Figure 44. Footprint Sheet - Inputs

Vehicle Type	Model Year	Annual Vehicle Mileage	Fuel Use																		
			Gasoline (gal)	Diesel (gal)	Gasoline HEV (gal)	Gasoline PHEV (gal)	Gasoline PHEV (kWh)	Gasoline EREV (gal)	Gasoline EREV (kWh)	Electricity (kWh)	G.H2 (kg)	Diesel HEV (gal)	Diesel HHV (gal)	B20 (gal)	B100 (gal)	E85 (gal)	LPG (gal)	CNG (GGE)	LNG (gal)	LNG / Diesel (LNG gal)	LNG / Diesel (diesel gal)
Passenger Car																					
Passenger Car																					
Passenger Car																					
Passenger Truck																					
Passenger Truck																					
Passenger Truck																					
Light Commercial Truck	2005	25,000	1,667																		
Light Commercial Truck	2004	23,475	1,565																		
Light Commercial Truck																					
School Bus																					
School Bus																					
School Bus																					
Transit Bus	2006	35,600		17,800																	
Transit Bus	2000	31,055		15,528																	
Transit Bus	2003	33,125		16,563																	
Refuse Truck																					
Refuse Truck																					
Refuse Truck																					
Single Unit Short-Haul Truck																					
Single Unit Short-Haul Truck																					
Single Unit Short-Haul Truck																					
Single Unit Long-Haul Truck																					
Single Unit Long-Haul Truck																					
Single Unit Long-Haul Truck																					
Combination Short-Haul Truck																					
Combination Short-Haul Truck																					
Combination Short-Haul Truck																					
Combination Long-Haul Truck																					
Combination Long-Haul Truck																					
Combination Long-Haul Truck																					

Figure 45. Footprint Sheet - Energy Use, Emissions, and Externality Cost Calculations

Vehicle Type	Petroleum Use (barrels)	GHG (short tons)	Vehicle Operation Air Pollutant Emissions (lb)								Externality Cost - Petroleum Use	Externality Cost - GHGs	Externality Cost - Vehicle Operation Air Pollutant Emissions							
			CO	NOx	PM10	PM10 (TBW)	PM2.5	PM2.5 (TBW)	VOC	VOC (Evap)			CO	NOx	PM10	PM10 (TBW)	PM2.5	PM2.5 (TBW)	VOC	VOC (Evap)
Passenger Car	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Passenger Car	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Passenger Car	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Passenger Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Passenger Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Passenger Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Light Commercial Truck	34.8	19.6	262.5	25.0	0.5	1.5	0.4	0.4	9.1	1.9	\$540	\$732	\$0	\$2	\$0	\$7	\$24	\$21	\$51	\$11
Light Commercial Truck	32.7	18.4	338.5	37.5	0.5	1.4	0.5	0.4	19.0	2.0	\$507	\$688	\$0	\$2	\$0	\$7	\$26	\$20	\$106	\$11
Light Commercial Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
School Bus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
School Bus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
School Bus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Transit Bus	445.9	244.4	220.5	686.7	45.1	4.3	43.8	1.1	45.7	0.0	\$6,920	\$9,125	\$0	\$45	\$8	\$20	\$2,411	\$60	\$255	\$0
Transit Bus	388.9	213.2	630.4	1,048.8	58.3	3.8	56.6	1.0	95.4	0.0	\$6,037	\$7,960	\$0	\$69	\$10	\$17	\$3,114	\$53	\$532	\$0
Transit Bus	414.9	227.4	247.2	639.5	46.4	4.0	45.0	1.0	52.3	0.0	\$6,439	\$8,491	\$0	\$42	\$8	\$18	\$2,477	\$56	\$292	\$0
Refuse Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Refuse Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Refuse Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Single Unit Short-Haul Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Single Unit Short-Haul Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Single Unit Short-Haul Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Single Unit Long-Haul Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Single Unit Long-Haul Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Single Unit Long-Haul Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Combination Short-Haul Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Combination Short-Haul Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Combination Short-Haul Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Combination Short-Haul Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Combination Long-Haul Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Combination Long-Haul Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Combination Long-Haul Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0

2.8 Footprint Outputs Sheet

This sheet summarizes the outputs of the Fleet Energy and Emissions Footprint Calculator with a table and graphs for petroleum use, GHGs, air pollutant emissions, and externality costs of the entire fleet (Figures 46-50). The following figures are shown as an example of the outputs generated; a user's results will vary depending on the specific inputs used.

Figure 46. Footprint Outputs Sheet - Energy Use and Emissions Summary Table

Vehicle Type	Petroleum Use (barrels)	GHG Emissions (short tons)	CO (lb)	NOx (lb)	PM10 (lb)	PM2.5 (lb)	VOC (lb)
Passenger Car	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Passenger Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Light Commercial Truck	67.5	38.0	600.9	62.5	4.0	1.7	32.0
School Bus	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Transit Bus	1,249.6	685.0	1,098.1	2,375.1	161.9	148.4	193.3
Refuse Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Single Unit Short-Haul Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Single Unit Long-Haul Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Combination Short-Haul Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Combination Long-Haul Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	1,317.1	723.0	1,699.0	2,437.5	165.9	150.1	225.4

Figure 47. Footprint Outputs Sheet – Externality Costs Summary Table

Vehicle Type	Petroleum Use (\$)	GHG Emissions (\$)	CO (\$)	NOx (\$)	PM10 (\$)	PM2.5 (\$)	VOC (\$)
Passenger Car	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Passenger Truck	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Light Commercial Truck	\$1,047	\$1,420	\$0	\$4	\$14	\$91	\$179
School Bus	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Transit Bus	\$19,397	\$25,577	\$0	\$157	\$82	\$8,172	\$1,078
Refuse Truck	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Single Unit Short-Haul Truck	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Single Unit Long-Haul Truck	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Combination Short-Haul Truck	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Combination Long-Haul Truck	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Total	\$20,444	\$26,997	\$0	\$161	\$96	\$8,263	\$1,257

Figure 48. Footprint Outputs Sheet – Fleet Energy Use and GHGs Summary Graph

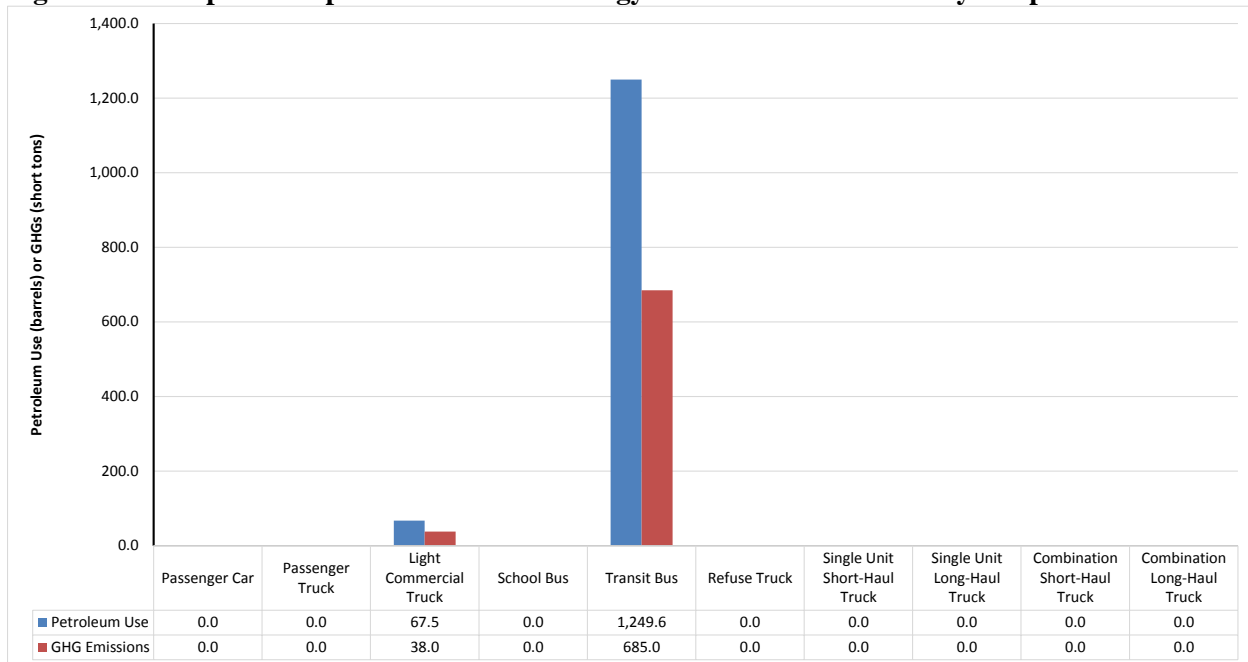


Figure 49. Footprint Outputs Sheet - Fleet Air Pollutant Emissions Summary Graph

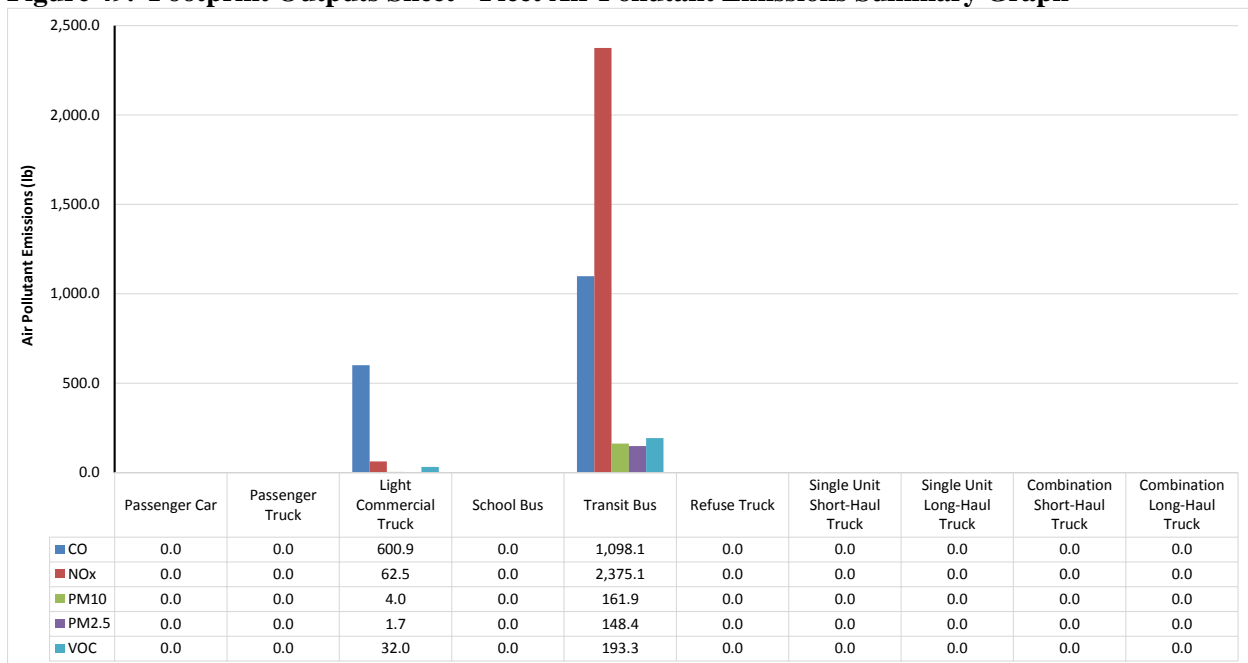
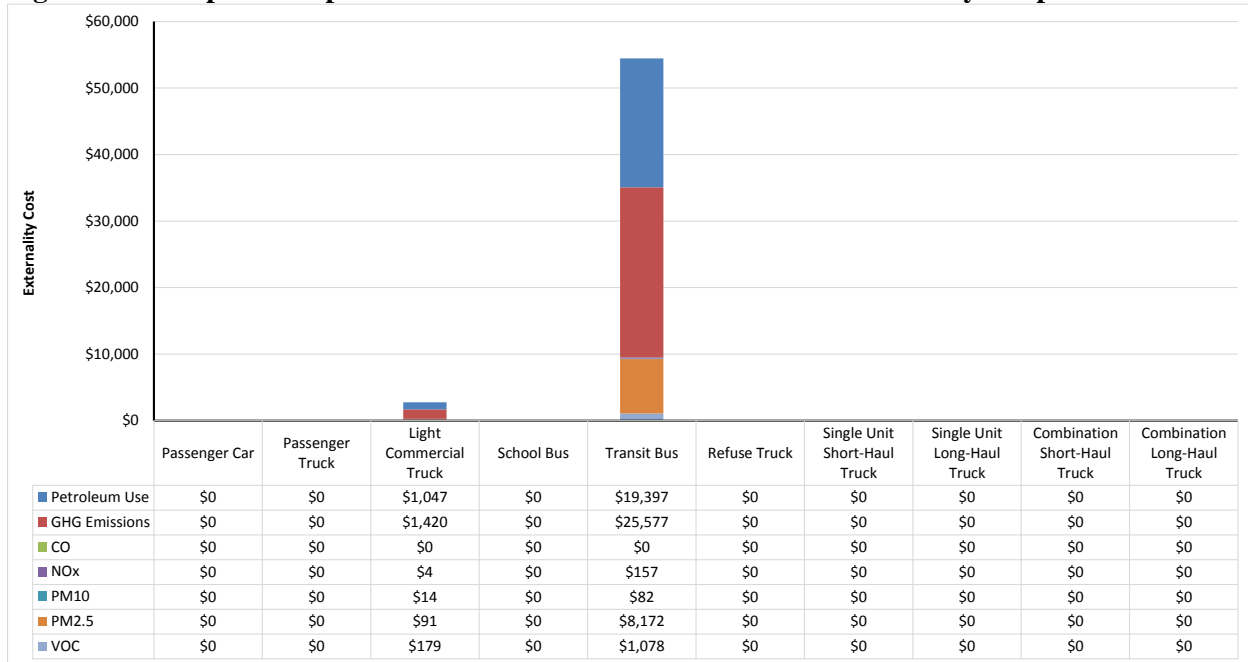


Figure 50. Footprint Outputs Sheet - Fleet Air Pollutant Emissions Summary Graph



2.9 Background Data Sheet

This sheet contains the background data for the Simple Payback, Total Cost of Ownership, and Fleet Energy and Emissions Footprint calculators. The user can navigate this sheet and jump to various sections by using the hyperlinks at the top of the page. As previously mentioned, a user can change the default vocation type using the dropdown boxes in this sheet (Figure 51). This will alter the lookup tables, which AFLEET Tool references for the default data of key inputs in the various sheets. Figure 52 shows an example of one look up table. Also mentioned previously, the user can input custom electricity mixes on this sheet (Figure 53). The Background Data sheet includes the source of assumptions and data for each input. Sometimes the sources are included in a comment for a specific cell. To view these comments, place the mouse cursor over a cell with a red triangle in its top left corner.

Figure 51. Background Data Sheet - AFLEET Look Up Tables - Vehicle Vocation Selection

Passenger Car	Car
Passenger Truck	Light-Duty Pickup Truck
Light Commercial Truck	Medium-Duty Pickup Truck
School Bus	School Bus
Transit Bus	Transit Bus
Refuse Truck	Refuse Truck
Single Unit Short-Haul Truck	Delivery Step Van
Single Unit Long-Haul Truck	Delivery Straight Truck
Combination Short-Haul Truck	Regional Haul Freight Truck
Combination Long-Haul Truck	Long Haul Freight Truck

Figure 52. Background Data Sheet - AFLEET Look Up Tables - New Vehicle Purchase Price

[illegible]

Figure 53. Background Data Sheet – GREET Fleet Specifications – Electricity Mix

			Alaska Systems Coordinating Council (ASCC)	Florida Reliability Coordinating Council (FRCC)	Hawaiian Islands Coordinating Council (HICC)	Midwest Reliability Organization (MRO)	Northeast Power Coordinating Council (NPCC)	Reliability First Corporation (RFC)	SERC Reliability Corporation (SERC)	Southwest Power Pool (SPP)	Texas Regional Entity (TRE)	Western Electricity Coordinating Council (WECC)	User Mix	
Residual oil	U.S. Average Mix	0.6%	12.6%	1.7%	70.3%	0.2%	1.4%	0.2%	0.4%	1.3%	0.1%	0.2%	0.6%	0.0%
Natural gas		26.2%	52.7%	60.2%	0.0%	2.6%	50.1%	15.9%	18.8%	22.7%	41.3%	32.5%	26.2%	
Coal		40.6%	9.6%	23.3%	13.7%	61.8%	2.6%	51.3%	49.3%	56.0%	36.0%	25.4%	40.6%	
Nuclear power		19.9%	0.0%	12.3%	0.0%	12.7%	28.3%	28.3%	28.3%	4.1%	12.3%	7.9%	19.9%	
Biomass		0.3%	0.8%	0.5%	3.2%	0.6%	0.6%	0.1%	0.4%	0.0%	0.2%	0.2%	0.3%	
Others (Wind, Solar, Hydro, etc)		12.4%	24.3%	2.0%	12.8%	22.6%	16.6%	4.1%	3.7%	15.9%	10.0%	33.8%	12.4%	

3. REFERENCES

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