User Guide for AFLEET Tool 2018

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November 2018

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ACKNOWLEDGEMENTS

This work was supported by the Vehicle Technologies Office, U.S. Department of Energy. The author gratefully thanks Linda Bluestein and Dennis Smith of Clean Cities for their sponsorship and technical guidance. Thanks are extended to Marcy Rood, Linda Gaines, Dan Santini, Marianne Mintz, Anant Vyas, Tom Stephens, Yan Zhou, and Michael Wang of Argonne National Laboratory for their comments. In addition, the author thanks all the external reviewers of the tool. Finally, special thanks to Ashwini Bharatkumar, Dana Johnson, Walter Schaefer, Kevin Lee, Luis Gomes, Kelly Vazquez, Josh Lin, Oscar Hermina-Tosado, Emelia Gold, Stephanie Taylor, Hao Cai, David Jura, and Krystal Krygowski for their help developing the tool. The author is responsible for this work and not the U.S. Department of Energy, Argonne National Laboratory, nor the reviewers.

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
CS	charge sustaining
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.H2	gaseous hydrogen
GHG	greenhouse gas
GREET	Greenhouse gases, Regulated Emissions, and Energy Use in Transportation
HDV	heavy-duty vehicle
HEV	hybrid electric vehicle
HHV	hydraulic hybrid vehicle
IR	idle reduction
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
RD100	blend of 100% renewable diesel by volume
RD20	blend of 20% renewable diesel and 80% diesel by volume
SO_x	sulfur oxides
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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November 2018

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.

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 petroleum use, greenhouse gas emissions, air pollutant emissions, and costs of ownership for light-duty vehicles (LDVs) and heavy-duty vehicles (HDVs). AFLEET Tool provides four 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. The third option is the Fleet 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. Finally, the Idle Reduction (IR) Calculator 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.

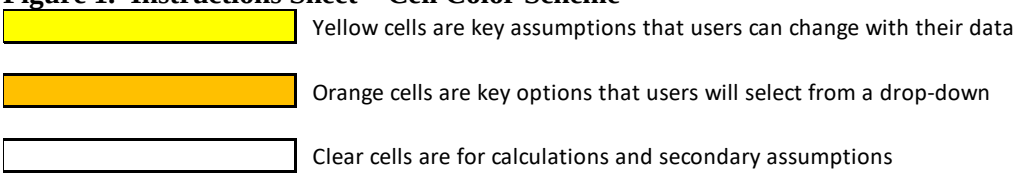
2. DESCRIPTION OF AFLEET TOOL

There are eleven 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



2.2 Inputs Sheet

The essential user inputs (Figure 2) for both the Simple Payback and Total Cost of Ownership calculators are shared between these two calculators and are located on the Inputs sheet. In addition, the Fleet Footprint Calculator and Idle Reduction Calculator use the vehicle location for air pollutant calculations, while the also IR Calculator uses fuel pricing.

- **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. A simple payback calculation estimates the amount of time in years, operating savings from an AFV to breakeven with the incremental cost above its conventional counterpart. When estimating a simple payback in AFLEET, 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 Payback and TCO Inputs

Primary Vehicle Location				
State	ILLINOIS			
County	COOK			
Light-Duty Vehicle Information				
Vehicle Type	Passenger Car			
Vocation Type	Car			
Light-Duty Fuel Type	**Number of Light-Duty Vehicles**	**Annual Vehicle Mileage**	**Fuel Economy (MPGGE)**	**Purchase Price ($/Vehicle)**
Gasoline	0	12,400	26.2	$20,000
Diesel	0	12,400	31.4	$22,500
Gasoline Hybrid Electric Vehicle (HEV)	0	12,400	36.4	$22,000
Gasoline Plug-in Hybrid Electric Vehicle (PHEV)	0	12,400	35.9	$28,000
Gasoline Extended Range Electric Vehicle (EREV)	0	12,400	35.6	$34,000
All-Electric Vehicle (EV)	0	12,400	72.1	$37,500
Gaseous Hydrogen (G.H2) Fuel Cell Vehicle (FCV)	0	12,400	55.0	$58,500
Biodiesel (B20)	0	12,400	31.4	$22,500
Biodiesel (B100)	0	12,400	31.4	$22,500
Renewable Diesel (RD20)	0	12,400	31.4	$22,500
Renewable Diesel (RD100)	0	12,400	31.4	$22,500
Ethanol (E85)	0	12,400	26.2	$20,000
Propane (LPG)	0	12,400	26.2	$26,000
Compressed Natural Gas (CNG)	0	12,400	24.9	$27,000
Heavy-Duty Vehicle Information				
Vehicle Type	Single Unit Short-Haul Truck			
Vocation Type	Delivery Step Van			
Heavy-Duty Fuel Type	**Number of Heavy-Duty Vehicles**	**Annual Vehicle Mileage**	**Fuel Economy (MPDGE)**	**Purchase Price ($/Vehicle)**
Gasoline	0	0	6.2	$0
Diesel	0	16,500	7.4	$65,000
All-Electric Vehicle (EV)	0	16,500	18.9	$145,000
Gaseous Hydrogen (G.H2) Fuel Cell Vehicle (FCV)	0	0	12.4	$0
Diesel Hybrid Electric Vehicle (HEV)	0	16,500	9.4	$83,000
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
Renewable Diesel (RD20)	0	16,500	7.4	$65,000
Renewable Diesel (RD100)	0	16,500	7.4	$65,000
Ethanol (E85)	0	0	6.2	$0
Propane (LPG)	0	16,500	6.2	$73,000
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	$0
Refueling Information				
Fueling Type	Public Station	Infrastructure costs (go to 'Payback')		
Fuel Price Sensitivity	No	Enter fuel price range (go to 'Payback')		
Fuel and DEF Price				
	Fuel Unit	**Public Station ($/Fuel Unit)**	**Private Station ($/Fuel Unit)**	
Gasoline	gasoline gallon	$2.29	$2.35	
Diesel	diesel gallon	$2.27	$1.67	
Electricity	kWh	$0.13	$0.13	
G.H2	hydrogen kg	$12.18	$12.68	
B20	B20 gallon	$2.33	$1.80	
B100	B100 gallon	$2.81	$3.25	
RD20	RD20 gallon			
RD100	RD100 gallon			
E85	E85 gallon	$2.18	$2.19	
Propane	LPG gallon	$2.61	$1.76	
CNG	CNG GGE	$2.38	$1.93	
LNG	LNG gallon	$2.70	$2.28	
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 2015). 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 "vocation type" and modify the default vehicle 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)**
- **renewable diesel 20% blend (RD20)**
- **renewable diesel 100% blend (RD100)**
- **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**
- **RD20**
- **RD100**
- **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**
- **percent down payment**
- **discount factor**

Figure 3. Inputs Sheet - Total Cost of Ownership Inputs

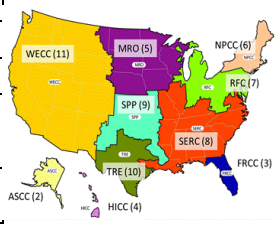
Light-Duty Vehicle Information			
Years of Planned Ownership	years	15	
Heavy-Duty Vehicle Information			
Years of Planned Ownership	years	15	
Infrastructure Information			
Years of Planned Ownership	years	15	
Financial Assumptions			
		Vehicles	**Infrastructure**
Loan	yes/no	No	No
Loan Term	years	5	5
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. The electricity mix is set by default to the appropriate EIA NERC based on the state and county inputted. The mix can still be changed using the dropdown box. 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	1	
	2 - Canola		
	3 - Corn		
	4 - Tallow		
Renewable Diesel Feedstock Source	1 - Soy	1	
	2 - Tallow		
	3 - Palm		
Ethanol Feedstock Source	1 - Corn	1	
	2 - Switchgrass		
	3 - Sugarcane		
	4 - Grain Sorghum		
CNG Feedstock Source	1 - North American NG	1	
	2 - Landfill Gas		
	3 - AD Gas of Animal Waste		
	4 - AD Gas of Wastewater Sludge		
	5 - AD Gas of MSW		
LNG Feedstock Source	1 - North American NG	1	
	2 - Landfill Gas		
	3 - AD Gas of Animal Waste		
	4 - AD Gas of Wastewater Sludge		
	5 - AD Gas of MSW		
North American NG Feedstock Source		Conventional	Shale
		66%	34%
LPG Feedstock Source		NG	Petroleum
		69%	31%
Source of Electricity for PHEVs, EVs, and FCVs (Electrolysis)		7	
	1 - Average U.S. Mix		
	2 to 11 - EIA Region Mix (see map)		
	12 - User Defined (go to 'Background Data' sheet)		
G.H2 Production Process	1 - Refueling Station SMR (On-site)	1	
	2 - Central Plant SMR (Off-site)		
	3 - Refueling Station Electrolysis (On-site)		



Number	Grid Mix
1	U.S.
2	ASCC
3	FRCC
4	HICC
5	MRO
6	NPCC
7	RFC
8	SERC
9	SPP
10	TRE
11	WECC
12	User Defined
7	**Default based on State and County**

By default AFLEET's petroleum use and GHG calculations have been 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 co-efficients (Argonne 2018a). 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.

The user can look at the petroleum use, GHGs, and air pollutants (Figure 5) of vehicle production, also known as the vehicle cycle. A vehicle cycle analysis includes raw material recovery, material processing, vehicle component production, vehicle assembly, vehicle disposal, and material recycling. For example, the results show the impacts of the additional weight and materials needed for an electric car versus a gasoline car. These co-efficients are generated from the GREET vehicle-cycle model (Argonne 2018b). This feature is only available for LDVs as no HDVs are examined in the current GREET vehicle cycle model. We use GREET's PHEV20, PHEV40 and EV300 results as default for AFLEET 2018's PHEV, EREV, and EV, respectively. For AFLEET 2018, we generated results for the following vehicles not included in GREET by default: diesel, biodiesel, renewable diesel, E85, LPG, and CNG. This was done by modifying the gasoline vehicle weight using data from Autonomie model results (Moawad 2016).

Figure 5. Inputs Sheet – Petroleum Use, GHGs & Air Pollutant Calculation Options

Petroleum Use, GHGs & Air Pollutant Calculation Type		1
1 - Well-to-Wheels Petroleum Use and GHGs & Vehicle Operation Air Pollutants		
2 - Well-to-Wheels Petroleum Use, GHGs, and Air Pollutants		
3 - Well-to-Wheels & Vehicle Production* Petroleum Use, GHGs, Air Pollutants (*LDVs only)		
Diesel In-Use Emissions Multiplier	yes/no	No
Low NOx Engines - CNG and LNG HDVs	yes/no	Yes

For air pollutants, the location where they are emitted is important, as they impact local air quality. Thus, air quality management organizations and other Clean Cities stakeholders are primarily interested in vehicle operation emissions, as upstream (WTP) emissions often occur a significant distance from where the vehicle is used. By default AFLEET's air pollutant calculations have been for vehicle operation only. 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 user can look at upstream (WTP) air pollutant emissions and (as mentioned before) vehicle cycle air pollutants (Figure 5). Users may want to examine upstream air pollutant emissions to calculate electricity production emissions and how they compare to gasoline vehicle air pollutant emissions. These co-efficients are generated from the GREET fuel-cycle model (Argonne 2018a). In addition, sulfur oxides (SO_x) were added to AFLEET during a previous update, as it is an important emission from electricity production and is also produced by combusting some vehicle fuels. SO_x emissions for vehicle operation, upstream, and vehicle production are all calculated using GREET co-efficients. MOVES is not used for vehicle operation SOx, as these emissions can be calculated via a sulfur balance, i.e. amount of sulfur in the fuel directly impacts SO_x emissions.

Recent analyses have found that diesel in-use emissions are much higher than their laboratory certification results (Cai 2017, Anenberg 2017). Diesel NO_x is driven by the type and performance of its aftertreatment systems, which can be highly duty-cycle dependent. For diesel LDVs, high speeds and accelerations may cause higher emissions (Anenberg 2017), while for diesel HDVs long idle times, low speeds, and low loads can cause higher NO_x (Cai 2017). While data for in-use NO_x of new diesels is limited, but analyses have shown that the MOVES model is most likely underestimating diesel NO_x (Anenberg 2017, Sandhu 2017). For AFLEET 2018, the option use diesel in-use multipliers is available to provide sensitivity cases as compared to the default MOVES results. In AFLEET 2018, the diesel in-use multiplier is 5.0 for diesel LDVs (Anenberg 2017), 4.0 for diesel HDVs (transit, school, refuse, single unit short-haul) in low speed duty cycles and 1.5 for diesel HDVs (combination and single unit long-haul, combination short-haul) in high speed duty cycles (Sandhu 2017, Cai 2017, EPA 2015).

Also previously added, was a low-NOx engine option for CNG and LNG heavy-duty vehicles (Cai 2017). Because of severe air quality concerns in California, CARB adopted optional low NOx heavy duty standards. As of now only, natural gas vehicles have demonstrated

the in-use performance (Cai 2017). If more AFVs demonstrate lower emissions, this feature will be expanded. For natural gas HDVs, low-NOx will be the primary engine type sold for model year 2018 (Cai 2017).

Another previous addition to AFLEET is the Idle Reduction Calculator. The essential user inputs (Figure 6), in addition to those mentioned previously (vehicle location and fuel pricing) are:

- **vehicle type**
- **vehicle model year**
- **annual idling and hotelling hours**
- **% of idle hours by service**
- **number of vehicles and IR equipment**
- **fuel consumption**
- **electrical power demand**
- **IR equipment price**.

Figure 6. Inputs Sheet – Idle Reduction Inputs

Light-Duty Vehicle Information										
IR Vehicle Type	Passenger Car									
IR Vocation Type	Police Car									
Baseline Vehicle Model Year	2017									
		Services Required (% of hours):								
Annual Idling Hours (per Vehicle)	1750	☑ Vehicle Heating	☑ Engine Heating	☑ Cooling	☑ Electrical					
% of Idle Hours by Service		33%	0%	33%	34%					
Light-Duty Baseline & IR Equipment	Number of Light-Duty Vehicles	Services Provided By IR Equipment				Idling Hour Reduction Goal		Fuel Consumption (GGE/hr)	Electrical Power Demand (W)	IR Equipment Price ($/Vehicle)
Gasoline	1							0.30		
Fuel Operated Air Heater	1	✓	✗	✗	✗	578		0.03	0	$900
Fuel Operated Coolant Heater	1	✗	✓	✗	✗	0		0.08	0	$1,250
Battery Management Start/Stop	1	✗	✗	✗	✓	595		0.00	250	$1,500
APU (Battery)	1	✗	✗	✓	✓	1173		0.00	250	$4,300
APU (Battery) & Fuel Operated Air Heater	1	✓	✗	✓	✓	1750		0.03	250	$5,200
APU (Battery) & Battery Management Start/Stop	1	✗	✗	✓	✓	1173		0.00	250	$5,800
Heavy-Duty Vehicle Information										
IR Vehicle Type	School Bus									
IR Vocation Type	School Bus									
Baseline Vehicle Model Year	2017									
		Services Required (% of hours):								
Annual Conventional Idling Hours (per Vehicle)	200	☑ Vehicle Heating	☑ Engine Heating	☑ Cooling	☑ Electrical					
% of Idle Hours by Service		33%	0%	33%	34%					
*Annual Hotelling Hours (per Vehicle)**	0	☑ Vehicle Heating	☑ Engine Heating	☑ Cooling	☑ Electrical					
% of Hotelling Hours by Service		33%	0%	33%	34%					
Heavy-Duty Baseline & IR Equipment	Number of Heavy-Duty Vehicles	Services Provided By IR Equipment				Conventional Idling Hour Reduction Goal	Hotelling Hour Reduction Goal	Fuel Consumption (DGE/hr)	Electrical Power Demand (W)	IR Equipment Price ($/Vehicle)
Diesel	1							0.75		
*Diesel (Hotelling)**								*0.00*		
Fuel Operated Air Heater	1	✓	✗	✗	✗	66	0	0.06	0	$1,800
Fuel Operated Coolant Heater	1	✗	✓	✗	✗	0	0	0.12	0	$1,700
Battery Management Start/Stop	1	✗	✗	✗	✓	68	0	0.00	1,300	$2,500
APU (Diesel)	1	✓	✓	✓	✓	200	0	0.20	0	$10,000
APU (Battery)	1	✗	✗	✓	✓	134	0	0.00	1,300	$8,000
APU (Battery) & Fuel Operated Air Heater	1	✓	✗	✓	✓	200	0	0.06	1,300	$9,800
APU (Battery) & Battery Management Start/Stop	1	✗	✗	✓	✓	134	0	0.00	1,300	$10,500
Truck Stop Electrification - Single System	1	✗	✗	✓	✓	134	0	0.00	0	$0
Shore Power	1	✗	✗	✓	✓	134	0	0.00	1,300	$2,500

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 and IR equipment to be compared as the default is set to zero. Similar to the Payback sheet, the IR Calculator estimates the amount of time in years, operating savings from IR equipment to breakeven with its purchase price (incremental cost) as compared to its conventional counterpart. When estimating a simple payback in AFLEET, the user must

enter data for both the IR equipment and their conventional counterpart (e.g. gasoline vehicle for LDVs and diesel vehicle for HDVs). We provide default idling and IR equipment fuel and electricity consumption. Default fuel pricing is based on the station type (public or private) and the state selected.

It is important for the user to select the services required by the fleet and the percent of idling hours that perform each service. In addition, each piece of IR equipment has its own capabilities in that it can provide ranging from one service to all services. Check boxes on the inputs page show a green check if the equipment can handle a certain service and a red "X" if it cannot. If the user chooses a piece of IR equipment that cannot handle all of the services provided by idling, the calculator will estimate the "leftover" idling hours remaining and use that info in the cost and environmental calculations. In AFLEET, the services idling and IR equipment can provide are:

- **vehicle heating**
- **engine heating**
- **cooling**
- **electrical**.

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 (PM_{10})** 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
- **Sulfur oxides (SO_x)** from tailpipe

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 7). 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 7. 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	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		
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		
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	31.4	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	$0.142		
Heavy-Duty Vehicle Inputs																
Vehicle Type	Single Unit Short-Haul Truck															
Number of HDVs	0	0				0	0	0	0	0	0	0	0	0	0	0
Annual Mileage	0	16,500				16,500	0	16,500	0	16,500	16,500	0	0	16,500	16,500	0
Fuel Economy (MPGGE)	5.3	6.4				17.6	10.6	8.1	8.3	6.4	6.4	5.3	5.3	5.4	5.4	6.1
Share of Alternative Fuel Use in Dual-Fuel or PHEV (Energy %)																95%
DEF Use (% of fuel consumption (GGE))	0%	2%				0%	0%	2%	2%	2%	2%	0%	0%	0%	0%	2%
Purchase Price ($/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 (CS) (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 can be found on FuelEconomy.gov. CD operation (i.e. EV mode) occurs when the vehicle is dependent on 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 8).

Figure 8. 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)				$5.34	$5.34											$3.13
Low Primary Fuel Price (% decrease vs default)	17%	19%	17%	17%	17%	0%	0%	19%	19%	0%	0%	0%	0%	0%	0%	0%
Low Primary Fuel Price ($/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)				$5.34	$5.34											$2.13
Private Fuel Price Sensitivity Case	No															
High Fuel Price (% increase vs default)	18%	19%	17%	17%	17%	0%	0%	19%	19%	0%	0%	0%	0%	0%	0%	0%
High Primary Fuel Price ($/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)				$5.34	$5.34											$3.13
Low Primary Fuel Price (% decrease vs default)	18%	19%	17%	17%	17%	0%	0%	19%	19%	0%	0%	0%	0%	0%	0%	0%
Low Primary Fuel Price ($/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)				$5.34	$5.34											$2.13

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, renewable diesel, 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 9). 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 9. 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: Time-Fill	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 & Mainten	$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	$0
Default Annual Private Station/EVSE O&M Costs ($	$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 Lat	$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. Starting with AFLEET Tool 2016, incremental vehicle purchase and infrastructure costs are included for acquisition costs.

The state emission factors used in the emission calculations are based on a new vehicle (model year 2018 for AFLEET Tool 2018). However, for the annual calculations used in this sheet we used a deterioration rate from MOVES based on a 30-year lifetime (weighted on assumed mileage driven each year) to account for vehicle operation air pollutant emission rates increasing as a vehicle ages. 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 2018, we used the most recent GREET model (Argonne 2018a). The 2018 version of GREET includes a HDV module which has estimates of HDV air pollutant emissions (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 supply risk 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 (AP2) model, which calculates the marginal damages corresponding to SO_2, VOC, NO_x, $PM_{2.5}$, PM_{10}, and NH_3 emissions (Jaramillo and Muller 2016, Muller 2017). From this model, we use the VOC, NO_x, $PM_{2.5}$, and PM_{10} data. Currently, AP2 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 2018, 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 10-12), 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 13-17). 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 10. 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 & Infrastructu		$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						**35.4**			**3.8**		**No payback**			**9.1**	
HD High Fuel Price Sensitivity						22.1			3.3		No payback			3.8	
HD Low Fuel Price Sensitivity						88.9			4.6		No payback			No payback	

Figure 11. 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 12. 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						**22.4**			**3.0**		**No payback**			**4.6**	
HD High Fuel Price Sensitivity						16.3			2.7		No payback			2.7	
HD Low Fuel Price Sensitivity						36.2			3.5		No payback			16.8	

Figure 13. Payback Outputs Sheet – LDV Simple Payback with and without Externalities Graph

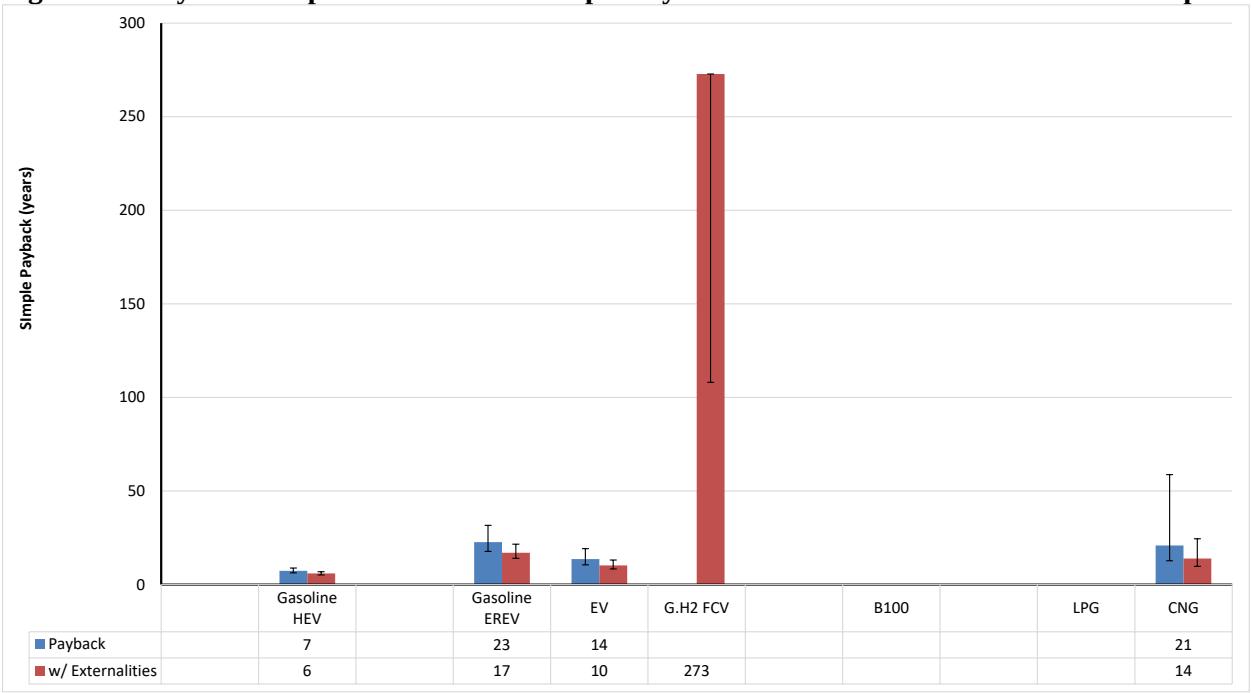
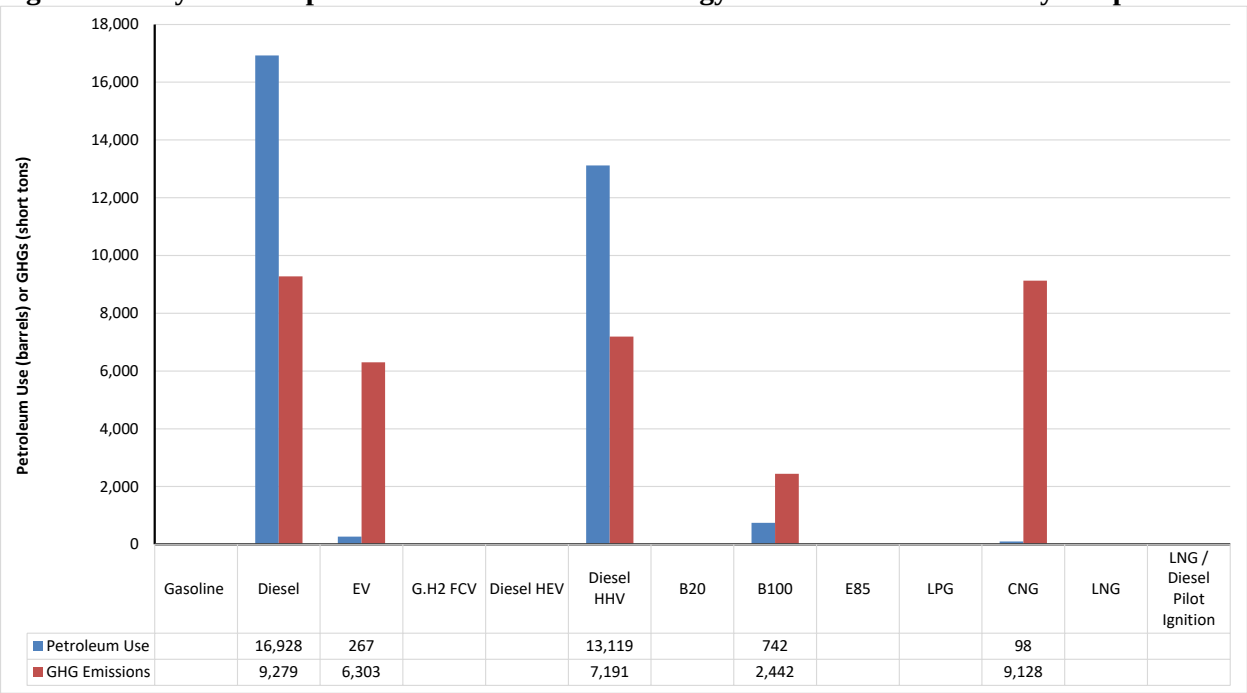
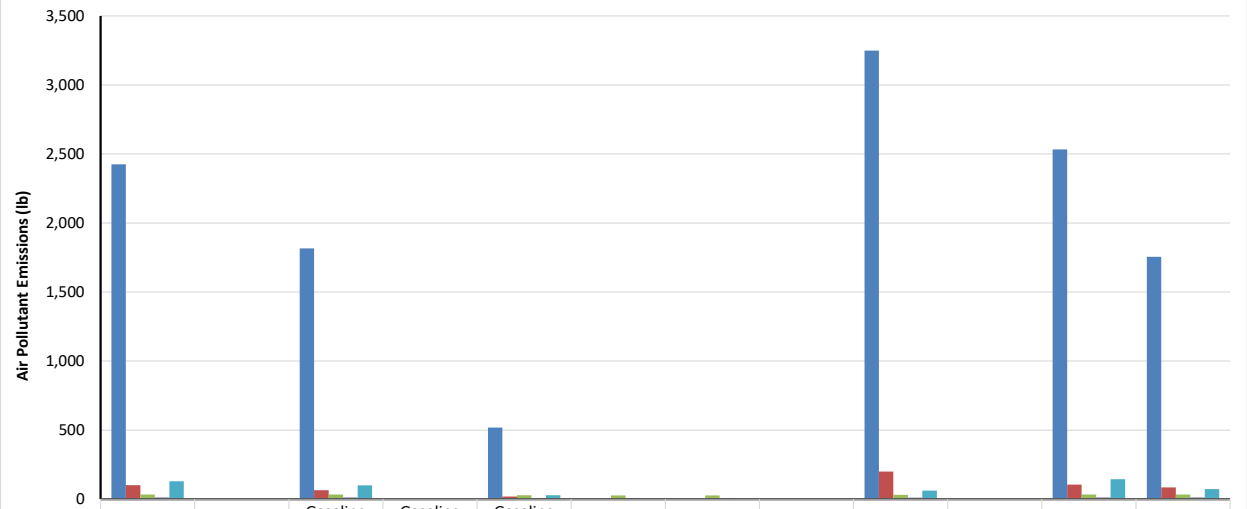


Figure 14. Payback Outputs Sheet – Annual HDV Energy Use and GHGs Summary Graph



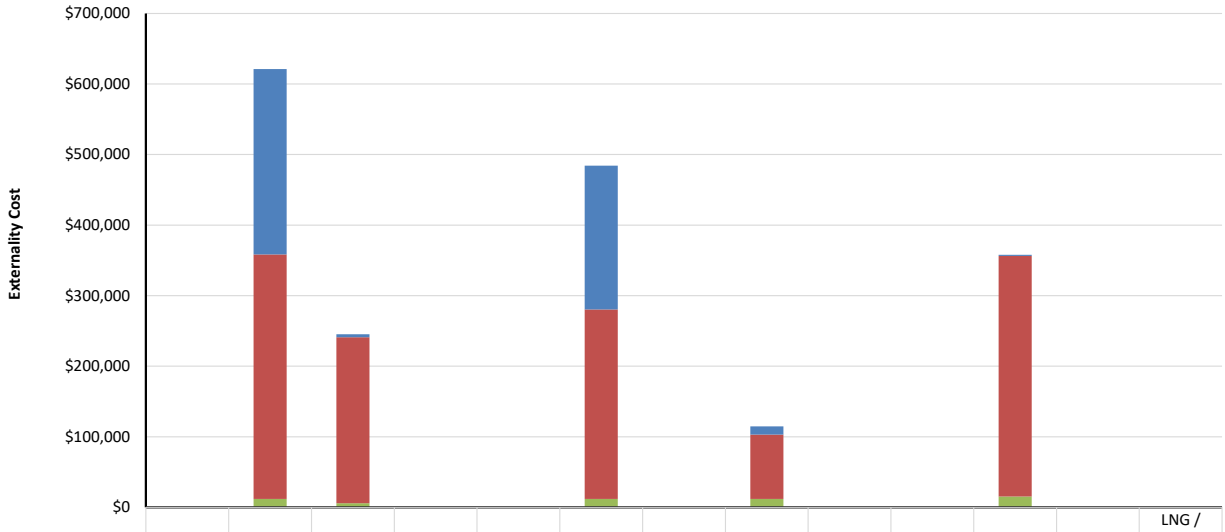
	Gasoline	Diesel	EV	G.H2 FCV	Diesel HEV	Diesel HHV	B20	B100	E85	LPG	CNG	LNG	LNG / Diesel Pilot Ignition
Petroleum Use		16,928	267			13,119		742			98		
GHG Emissions		9,279	6,303			7,191		2,442			9,128		

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



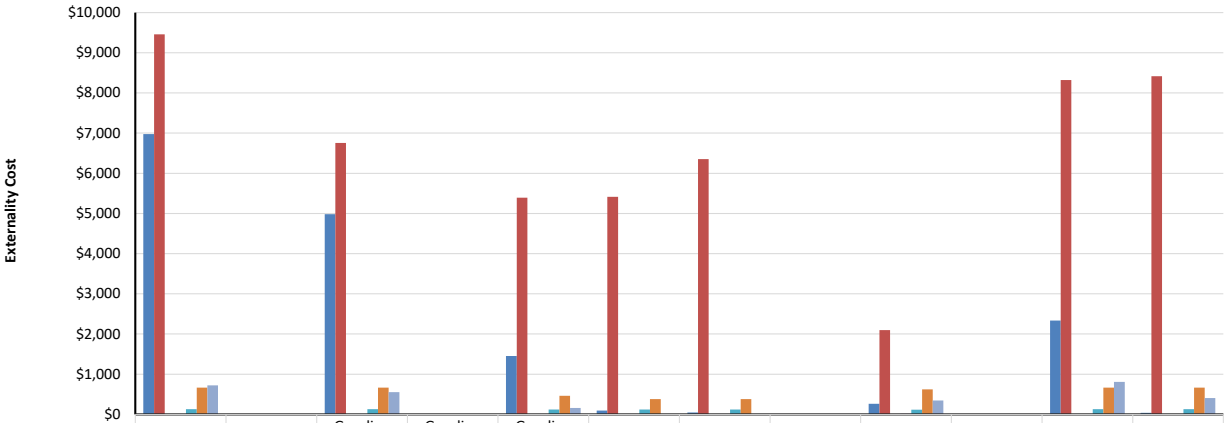
	Gasoline	Diesel	Gasoline HEV	Gasoline PHEV	Gasoline EREV	EV	G.H2 FCV	B20	B100	E85	LPG	CNG
CO	2,425		1,816		518	0	0		3,248		2,532	1,755
NOx	101		65		19	0	0		200		105	84
PM10	33		33		28	26	26		30		33	33
PM2.5	12		12		8	7	7		11		12	12
VOC	130		99		28	0	0		62		145	73

Figure 16. Payback Outputs Sheet – Annual HDV Annual Externality Costs Graph



	Gasoline	Diesel	EV	G.H2 FCV	Diesel HEV	Diesel HHV	B20	B100	E85	LPG	CNG	LNG	LNG / Diesel Pilot Ignition
Petroleum Use		$262,752	$4,140			$203,633		$11,519			$1,514		
GHGs		$346,470	$235,358			$268,514		$91,183			$340,858		
Air Pollutants		$12,021	$5,804			$12,021		$12,021			$15,404		

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



	Gasoline	Diesel	Gasoline HEV	Gasoline PHEV	Gasoline EREV	EV	G.H2 FCV	B20	B100	E85	LPG	CNG
Petroleum Use	$6,976		$4,983		$1,453	$95	$45		$265		$2,336	$37
GHGs	$9,460		$6,757		$5,394	$5,413	$6,354		$2,097		$8,322	$8,417
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

2.5 TCO Sheet

This sheet contains the Total Cost of Ownership Calculator, which evaluates the net present value of operating and fixed costs of a a new vehicle over the years of planned ownership, 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" (Figure 18), 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 (Figure 19, 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, the tool will calculate the net present value of a vehicle purchase. In addition, lifetime petroleum use, GHGs, air pollutant emissions, and externality costs are also calculated (Figure 19). 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 a 30-year lifetime (weighted on assumed mileage driven each year).

Figure 18. 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	$/year		$0	$0	$0	$0	$0
Costs	$/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 19. TCO Sheet – LDV Energy Use and Emissions and Externality Costs Calculations

Total Cost of Ownership Calculator	Project Year	1	2	3	4	5
Annual Gasoline Passenger Car Fleet Petroleum Use, GHGs, and Air Pollutants						
Well-to-Wheels Petroleum and GHGs						
LD Petroleum Use	barrels/year	98.7	98.7	98.7	98.7	98.7
LD GHGs	short ton/year	57.5	57.5	57.5	57.5	57.5
Vehicle Production Petroleum and GHGs						
LD Petroleum Use	barrels/year	0.0	0.0	0.0	0.0	0.0
LD GHGs	short ton/year	0.0	0.0	0.0	0.0	0.0
Vehicle Operation Air Pollutants						
CO	lb/year	226.5	227.8	228.7	391.2	393.7
NOx	lb/year	12.8	12.8	13.0	19.0	19.0
PM10	lb/year	0.8	0.8	0.8	0.8	0.8
PM10 (TBW)	lb/year	9.6	9.6	9.6	9.6	9.6
PM2.5	lb/year	0.5	0.5	0.5	0.7	0.7
PM2.5 (TBW)	lb/year	1.4	1.4	1.4	1.4	1.4
VOC	lb/year	13.0	13.4	13.8	19.1	19.5
VOC (Evap)	lb/year	8.5	8.5	8.5	8.5	8.5
SOx	lb/year	1.4	1.4	1.4	1.4	1.4
Upstream Air Pollutants						
CO	lb/year	0.0	0.0	0.0	0.0	0.0
NOx	lb/year	0.0	0.0	0.0	0.0	0.0
PM10	lb/year	0.0	0.0	0.0	0.0	0.0
PM10 (TBW)	lb/year	0.0	0.0	0.0	0.0	0.0
PM2.5	lb/year	0.0	0.0	0.0	0.0	0.0
PM2.5 (TBW)	lb/year	0.0	0.0	0.0	0.0	0.0
VOC	lb/year	0.0	0.0	0.0	0.0	0.0
VOC (Evap)	lb/year	0.0	0.0	0.0	0.0	0.0
SOx	lb/year	0.0	0.0	0.0	0.0	0.0
Vehicle Production Air Pollutants						
CO	lb/year	0.0	0.0	0.0	0.0	0.0
NOx	lb/year	0.0	0.0	0.0	0.0	0.0
PM10	lb/year	0.0	0.0	0.0	0.0	0.0
PM10 (TBW)	lb/year	0.0	0.0	0.0	0.0	0.0
PM2.5	lb/year	0.0	0.0	0.0	0.0	0.0
PM2.5 (TBW)	lb/year	0.0	0.0	0.0	0.0	0.0
VOC	lb/year	0.0	0.0	0.0	0.0	0.0
VOC (Evap)	lb/year	0.0	0.0	0.0	0.0	0.0
SOx	lb/year	0.0	0.0	0.0	0.0	0.0
Annual Gasoline Passenger Car Fleet Petroleum Use, GHG, and Air Pollutant Externality Costs						
Well-to-Wheels Petroleum and GHG Externality Costs						
Petroleum Use	$/year	$1,552	$1,589	$1,627	$1,666	$1,706
GHGs	$/year	$2,172	$2,225	$2,278	$2,333	$2,389
Vehicle Production Petroleum and GHG Externality Costs						
LD Petroleum Use	$/year	$0	$0	$0	$0	$0
LD GHGs	$/year	$0	$0	$0	$0	$0
Vehicle Emissions Air Pollutant Externality Costs						
CO	$/year	$0	$0	$0	$0	$0
NOx	$/year	$147	$150	$157	$235	$240
PM10	$/year	$7	$7	$7	$1	$1
PM10 (TBW)	$/year	$203	$208	$213	$218	$223
PM2.5	$/year	$127	$130	$133	$205	$210
PM2.5 (TBW)	$/year	$353	$362	$370	$379	$388
VOC	$/year	$235	$248	$262	$371	$387
VOC (Evap)	$/year	$153	$156	$160	$164	$168
SOx	$/year	$83	$85	$87	$89	$91
Upstream Air Pollutant Externality Costs						
CO	$/year	$0	$0	$0	$0	$0
NOx	$/year	$0	$0	$0	$0	$0
PM10	$/year	$0	$0	$0	$0	$0
PM10 (TBW)	$/year	$0	$0	$0	$0	$0
PM2.5	$/year	$0	$0	$0	$0	$0
PM2.5 (TBW)	$/year	$0	$0	$0	$0	$0
VOC	$/year	$0	$0	$0	$0	$0
VOC (Evap)	$/year	$0	$0	$0	$0	$0
SOx	$/year	$0	$0	$0	$0	$0
Vehicle Production Air Pollutant Externality Costs						
CO	$/year	$0	$0	$0	$0	$0
NOx	$/year	$0	$0	$0	$0	$0
PM10	$/year	$0	$0	$0	$0	$0
PM10 (TBW)	$/year	$0	$0	$0	$0	$0
PM2.5	$/year	$0	$0	$0	$0	$0
PM2.5 (TBW)	$/year	$0	$0	$0	$0	$0
VOC	$/year	$0	$0	$0	$0	$0
VOC (Evap)	$/year	$0	$0	$0	$0	$0
SOx	$/year	$0	$0	$0	$0	$0

Total Petroleum Use, GHGs, and Air Pollutants & Externality Costs - Per Lifetime Ownership of Gasoline Passenger Car Fleet

Petroleum Use	**barrels**	**1,481**	**$27,626**
GHGs	**short tons**	**862**	**$38,675**
CO	**pounds**	**6,986**	**$0**
NOx	**pounds**	**383**	**$5,402**
PM10	**pounds**	**162**	**$3,730**
PM2.5	**pounds**	**35**	**$10,817**
VOC	**pounds**	**563**	**$12,433**
SOx	**pounds**	**20**	**$1,480**

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 20-22), both LDVs and HDVs are included, while LDVs and HDVs are presented separately in the graphs (Figures 23-30). This sheet has additional cost graphs as compared to the Payback Outputs sheet. Specically, the cumulative cost of ownership compared to a conventional counterpart (Figure 23) 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. Figure 24 shows the cumulative cash flow for both AFVs and conventional vehicles. Figure 25 shows the total cost of ownership broken down into the major cost categories: financing, depreciation, fuel, maintenance and repair, insurance, and license and registration. Figure 26 show the total cost of ownership but also include externalitiy 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 20. 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 21. 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			26,841		
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 22. 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 23. TCO Outputs Sheet – LDV Cumulative Cash Flow Compared to Gasoline Summary Graph

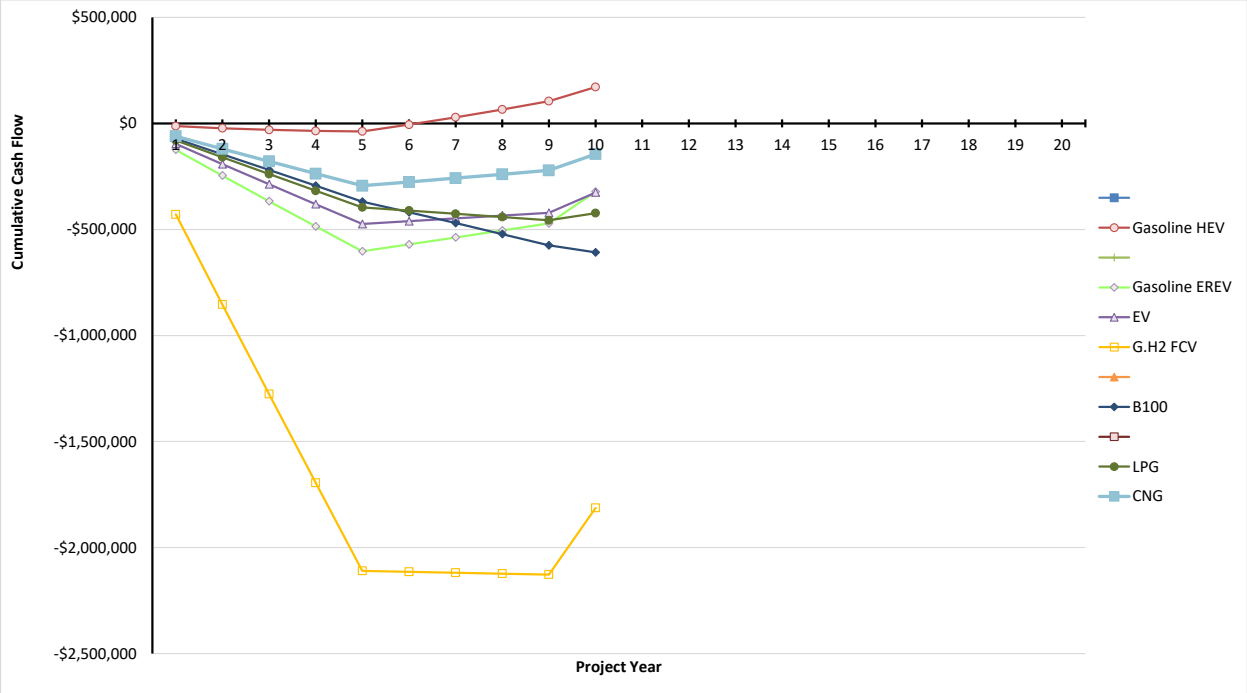


Figure 24. TCO Outputs Sheet – LDV Cumulative Cash Flow Summary Graph

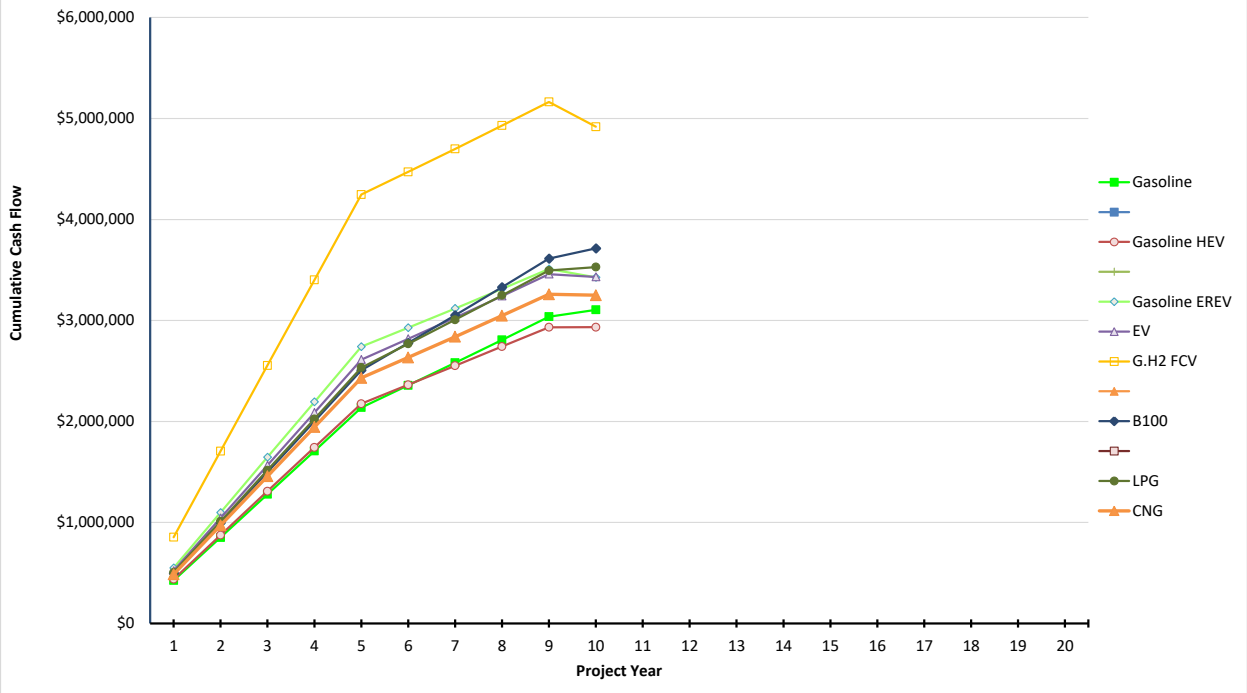
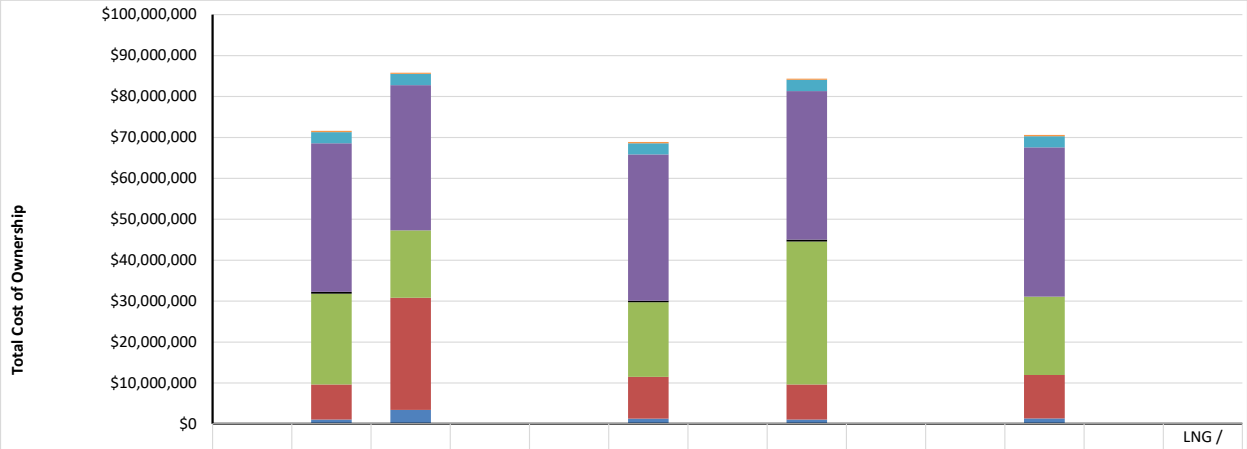
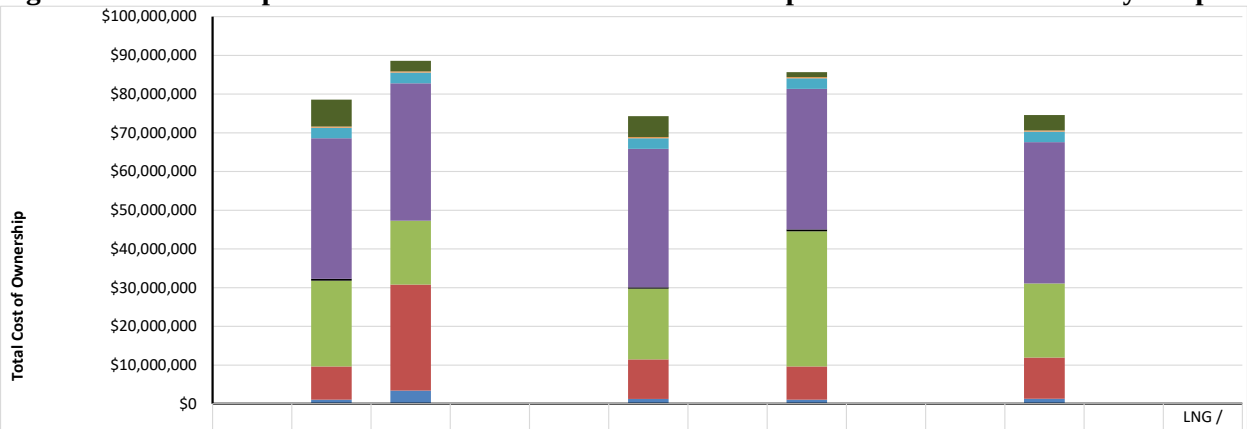


Figure 25. TCO Outputs Sheet – HDV Total Cost of Ownership Summary Graph



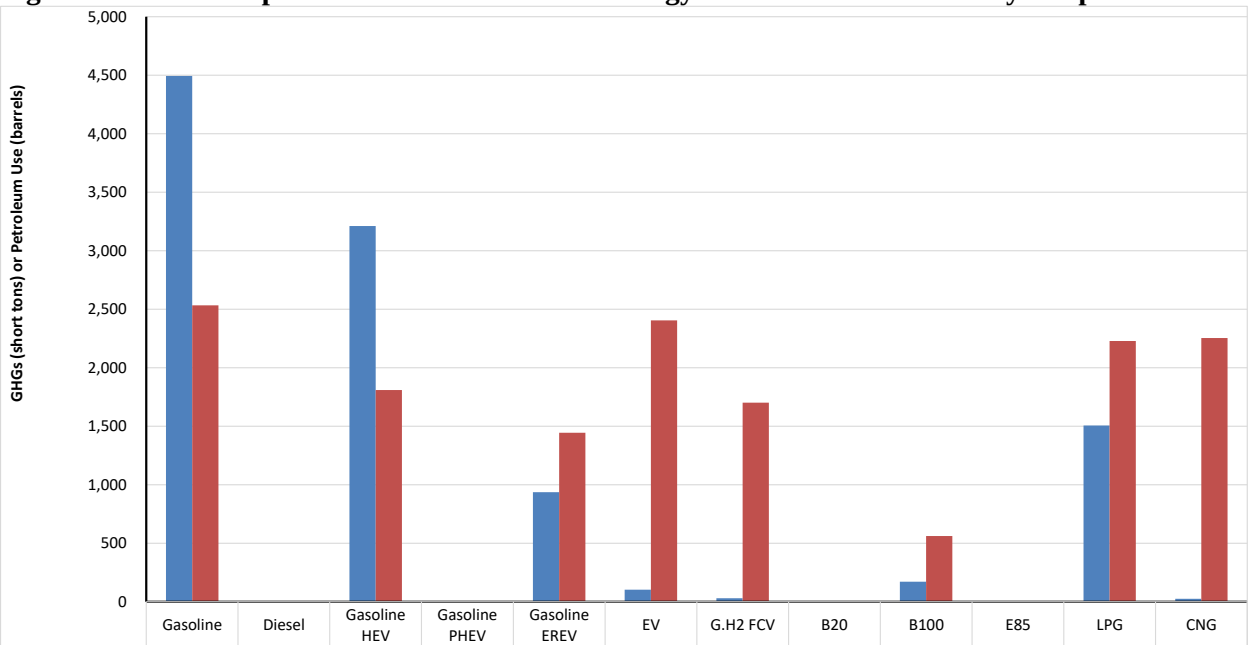
	Gasoline	Diesel	EV	G.H2 FCV	Diesel HEV	Diesel HHV	B20	B100	E85	LPG	CNG	LNG	LNG / Diesel Pilot Ignition
License and Registration		$289,726	$289,726			$289,726		$289,726			$289,726		
Insurance		$2,750,786	$2,750,786			$2,750,786		$2,750,786			$2,750,786		
Maintenance and Repair		$36,288,11	$35,509,71			$35,748,25		$36,288,11			$36,476,43		
Diesel Exhaust Fluid		$464,704	$0			$360,145		$464,704			$0		
Fuel		$22,157,10	$16,470,13			$18,241,77		$34,929,18			$19,134,85		
Depreciation		$8,584,525	$27,389,51			$10,219,67		$8,584,525			$10,628,46		
Financing		$1,072,935	$3,423,173			$1,277,304		$1,072,935			$1,328,396		

Figure 26. TCO Outputs Sheet – HDV Total Cost of Ownership w/ Externalities Summary Graph



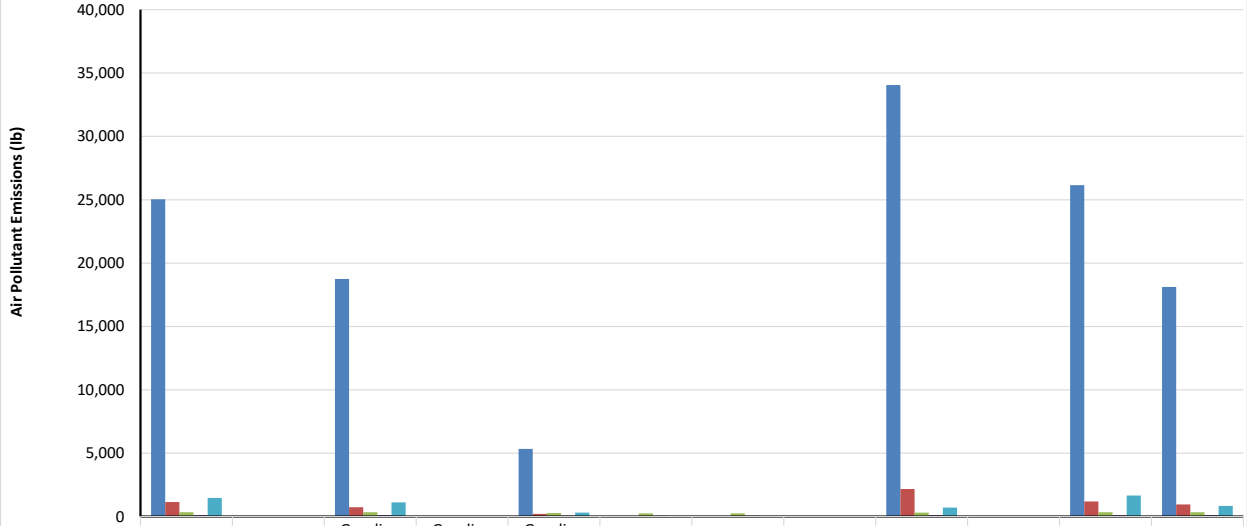
	Gasoline	Diesel	EV	G.H2 FCV	Diesel HEV	Diesel HHV	B20	B100	E85	LPG	CNG	LNG	LNG / Diesel Pilot Ignition
Externalities		$6,933,492	$2,741,081			$5,404,818		$1,284,731			$3,994,915		
License and Registration		$289,726	$289,726			$289,726		$289,726			$289,726		
Insurance		$2,750,786	$2,750,786			$2,750,786		$2,750,786			$2,750,786		
Maintenance and Repair		$36,288,11	$35,509,71			$35,748,25		$36,288,11			$36,476,43		
Diesel Exhaust Fluid		$464,704	$0			$360,145		$464,704			$0		
Fuel		$22,157,10	$16,470,13			$18,241,77		$34,929,18			$19,134,85		
Depreciation		$8,584,525	$27,389,51			$10,219,67		$8,584,525			$10,628,46		
Financing		$1,072,935	$3,423,173			$1,277,304		$1,072,935			$1,328,396		

Figure 27. TCO Outputs Sheet – Lifetime LDV Energy Use and GHGs Summary Graph



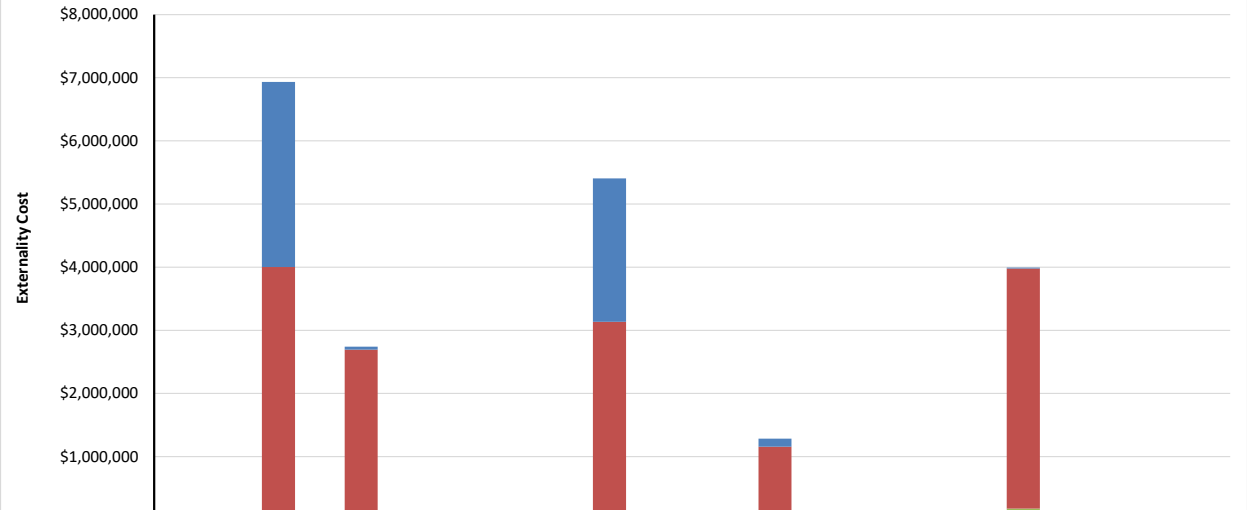
	Gasoline	Diesel	Gasoline HEV	Gasoline PHEV	Gasoline EREV	EV	G.H2 FCV	B20	B100	E85	LPG	CNG
Petroleum Use	4,494		3,210		936	102	29		171		1,505	24
GHG Emissions	2,533		1,810		1,445	2,404	1,702		562		2,229	2,254

Figure 28. TCO Outputs Sheet – Lifetime LDV Air Pollutant Emissions Summary Graph



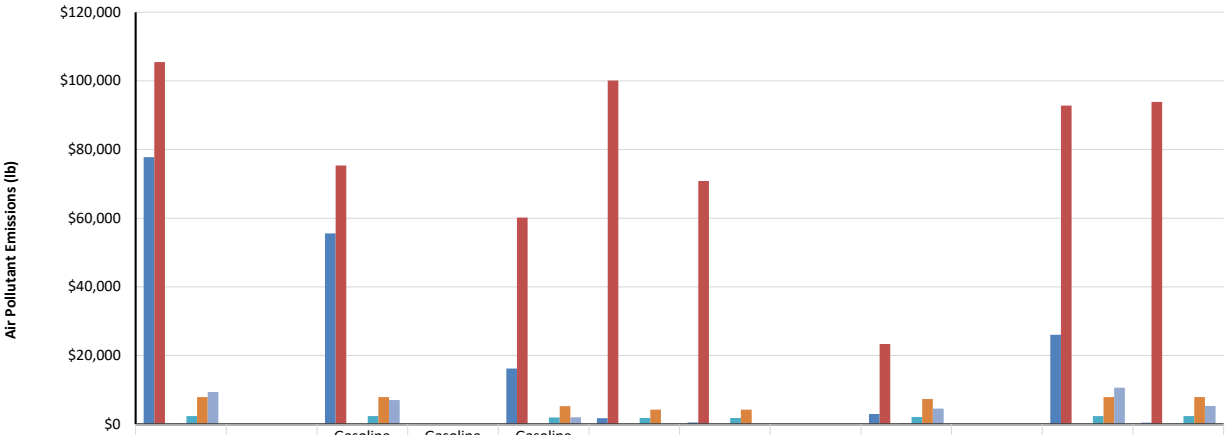
	Gasoline	Diesel	Gasoline HEV	Gasoline PHEV	Gasoline EREV	EV	G.H2 FCV	B20	B100	E85	LPG	CNG
CO	25,032		18,752		5,348	0	0		34,052		26,144	18,117
NOx	1,147		739		211	0	0		2,175		1,189	959
PM10	343		343		285	262	262		310		343	343
PM2.5	128		128		86	69	69		119		128	128
VOC	1,475		1,113		317	0	0		715		1,668	834

Figure 29. TCO Outputs Sheet – Lifetime HDV Externality Costs Summary Graph



	Gasoline	Diesel	EV	G.H2 FCV	Diesel HEV	Diesel HHV	B20	B100	E85	LPG	CNG	LNG	LNG / Diesel Pilot Ignition
Petroleum Use		$2,930,23	$46,172			$2,270,93		$128,459			$16,879		
GHGs		$3,863,86	$2,624,73			$2,994,49		$1,016,88			$3,801,28		
Air Pollutants		$139,384	$70,175			$139,384		$139,384			$176,748		

Figure 30. TCO Outputs Sheet – Lifetime LDV Detailed Externality Costs Summary Graph



	Gasoline	Diesel	Gasoline HEV	Gasoline PHEV	Gasoline EREV	EV	G.H2 FCV	B20	B100	E85	LPG	CNG
Petroleum Use	$77,794		$55,567		$16,202	$1,761	$503		$2,955		$26,056	$417
GHGs	$105,494		$75,353		$60,160	$100,108	$70,856		$23,388		$92,813	$93,871
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

2.7 IR Sheet

This sheet contains the Idle Reduction Calculator, which examines acquisition and annual operating costs as well as average annual petroleum use, GHGs, and air pollutant emissions. Key assumptions for light-duty vehicles, heavy-duty vehicles, and fuel price from the Inputs sheet are fed into the IR sheet; LDV inputs are shown as an example (Figure 31). Additional user inputs can be modified on this sheet for Battery Management Start/Stop and APU (Battery) charging type (engine or shore power) and usage. HDV inputs have the same structure but there are separated calculations for conventional idling, which is idling done during normal usage of a vehicle, and hotelling, which is for long-haul trucks that idle overnight.

Figure 31. IR Sheet – LDV IR Inputs

	Gasoline LDV (Baseline)	Diesel HDV (Baseline)	Fuel Operated Air Heater	Fuel Operated Coolant Heater	Battery Management Start/Stop	APU (Diesel)	APU (Battery)	APU (Battery) & Fuel Operated Air Heater	APU (Battery) & Battery Management Start/Stop	Truck Stop Electrification - Single System	Shore Power
Light-Duty Vehicle Inputs											
IR Vehicle Type	Passenger Car										
Number of LDVs	1		1	1	1		1	1	1		
Idle Reduction (IR) Equipment Cost ($/vehicle)			$900	$900	$1,500		$4,300	$5,200	$5,800		
Truck Stop Electrification Cost ($/hr)											
Electrical Power Demand (W)			0	0	250		250	250	250		
Charges/Day					1		1	1	1		
Days Driven/Week					5		5	5	5		
Weeks Driven/Year					52		52	52	52		
Battery Runtime (hr)					1.9		1.9	1.9	1.9		
Potential Battery/IR Use (hr/yr)					505		505	505	505		
Battery Share of Annual Idling Hours					85%		43%	43%	43%		
Charging Type					Engine		Engine	Engine	Engine		
% of Time Batteries Charged By Shore Power					0%		0%	0%	0%		
% of Time Batteries Charged By Engine					85%		43%	43%	100%		
Share of Annual Idling Hours Reduction Goal (%)			100%	100%	85%		43%	62%	100%		
IR Equipment Service Hours:											
Vehicle Heating			577.5	0	0		0	577.5	0		
Engine Heating			0	0	0		0	0	0		
Cooling			0	0	0		577.5	577.5	577.5		
Electrical			0	0	595		595	595	595		
Annual Idling Hours Reduction Goal	1,750		578	0	595		1,173	1,750	1,173		
IR Equipment Idling Hours Reduction Ability (%)			100%	100%	85%		43%	62%	100%		
Maximum Annual Idling Hours that IR Equipment Can Reduce			578	0	505		505	1,082	1,173		
Hours that IR Equipment Consumes Fuel			*578*	*0*				*578*			
Hours that IR Equipment Consumes Electricity					*505*		*505*	*505*	*1,173*		
Leftover Annual Idling Hours After IR Equipment	1,750		1,173	1,750	1,245		1,245	668	578		
Idling Fuel Consumption (GGE/hr)	0.299		0.299	0.299	0.299		0.299	0.299	0.299		
IR Equipment Fuel Consumption (GGE/hr)			0.035	0.081	0.000		0.000	0.035	0.000		
Fuel Consumption to Recharge Batteries (GGE/hr)					0.080		0.080	0.080	0.080		
IR Electricity Consumption (kWh/hr)					0.309		0.309	0.309	0.309		
LD Miles of Idling (mi/yr)	13,709		9,185	13,709	9,755		9,755	5,231	4,524		
LD Engine Maintenance Cost ($/mi)	$0.034		$0.034	$0.034	$0.034		$0.034	$0.034	$0.034		
LD Engine Maintenance Cost ($/yr)	$470		$315	$470	$334		$334	$179	$155		
IR Equipment Maintenance Cost ($/hr)			$0.069	#DIV/0!	$0.248		$0.248	$0.152	$0.107		
IR Equipment Maintenance Cost ($/yr)			$40	#DIV/0!	$125		$125	$165	$125		
Total LD Maintenance Cost ($/yr)	**$470**		**$355**	**#DIV/0!**	**$459**		**$459**	**$344**	**$280**		

The other tables in this sheet include the fuel price and fuel use calculation, simple payback calculations, petroleum use, GHG emissions, air pollutant emissions, and externality costs. The structure of the IR Calculator includes fuel use from idling, IR equipment, and to recharge batteries (for battery systems that do not use shore power), and electricity use from IR equipment. If the IR equipment is not able to provide certain services, the hours leftover are assumed to be idling, which are used in the cost and environmental calculations.

2.8 IR Outputs Sheet

This sheet summarizes the outputs of the IR 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 following figures are shown as an example of the outputs generated; a user's results will vary depending on the specific inputs used.

Figure 32. IR Outputs Sheet – Annual Costs Summary Table

	Gasoline LDV (Baseline)	Diesel HDV (Baseline)	Fuel Operated Air Heater	Operated Coolant Heater	Battery Managemen t Start/Stop	APU (Diesel)	APU (Battery)	(Battery) & Fuel Operated Air	(Battery) & Battery Managemen	Truck Stop Electrification - Single System	Shore Power
Acquisition Cost											
Light-Duty (LD) Fleet IR Equipment			$9,000	$9,000	$15,000		$43,000	$52,000	$58,000		
Heavy-Duty (HD) Fleet IR Equipment			$18,000	$17,000	$25,000	$100,000	$80,000	$98,000	$105,000	$50	$25,000
Annual Idling Operating Cost - Private Station Fueling											
LD Fleet	$16,997		$12,258		$14,152		$13,754	$9,015	$9,072		
HD Fleet		$32,348	$22,718		$27,397	$7,845	$25,693	$16,063	$17,739	$14,364	$13,339
Annual Idling Operating Savings - Private Station Fueling											
Compared to Gasoline LD Fleet Idling			$4,739		$2,844		$3,242	$7,981	$7,924		
Compared to Diesel HD Fleet Idling			$9,630		$4,951	$24,502	$6,655	$16,285	$14,609	$17,983	$19,008
Simple Payback (years)											
LD Passenger Car IR Equipment			**1.9**		**5.3**		**13.3**	**6.5**	**7.3**		
HD Combination Long-Haul Truck IR Equipment			**1.9**		**5.0**	**4.1**	**12.0**	**6.0**	**7.2**	**0.0**	**1.3**

Figure 33. IR Outputs Sheet – Annual Energy Use and Emissions Summary Table

	Gasoline LDV (Baseline)	Diesel HDV (Baseline)	Fuel Operated Air Heater	Operated Coolant Heater	Battery Managemen t Start/Stop	APU (Diesel)	APU (Battery)	(Battery) & Fuel Operated Air	(Battery) & Battery Managemen	Truck Stop Electrification - Single System	Shore Power
Annual Well-to-Wheels Idling Petroleum Use (barrels)											
LD Petroleum Use	109.2		77.3	109.2	84.8		81.3	49.5	55.7		
HD Petroleum Use		432.8	299.6	432.8	301.3	97.2	277.9	144.8	173.8	162.5	162.5
Annual Well-to-Wheels Idling GHGs (short tons)											
LD GHGs	63.5		45.0	63.5	49.4		47.3	28.8	32.4		
HD GHGs		245.4	169.9	245.4	170.9	55.1	157.6	82.1	98.5	97.9	97.9
Annual Vehicle Operation Idling Air Pollutants (lb)											
LD Passenger Car Fleet											
CO	0.78		2.05	0.78	0.55		0.55	1.82	0.26		
NOx	0.11		0.58	0.11	0.08		0.08	0.55	0.04		
PM10	0.09		0.11	0.09	0.07		0.07	0.09	0.03		
PM2.5	0.08		0.10	0.08	0.06		0.06	0.08	0.03		
VOC	0.02		0.14	0.02	0.02		0.02	0.14	0.01		
SOx	1.50		1.06	1.50	1.17		1.12	0.68	0.76		
HD Combination Long-Haul Truck Fleet											
CO		1.14	2.46	1.14	0.75	154.76	0.70	2.03	0.38	1.14	1.14
NOx		2.13	1.99	2.13	1.40	122.32	1.32	1.18	0.70	2.13	2.13
PM10		0.07	0.10	0.07	0.05	7.99	0.04	0.08	0.02	0.07	0.07
PM2.5		0.07	0.10	0.07	0.04	7.35	0.04	0.07	0.02	0.07	0.07
VOC		0.19	0.27	0.19	0.13	32.38	0.12	0.20	0.06	0.19	0.19
SOx		2.69	1.86	2.69	1.87	0.60	1.72	0.90	1.08	1.01	1.01

Figure 34. IR Outputs Sheet – Annual Externality Costs Summary Table

	Gasoline LDV (Baseline)	Diesel HDV (Baseline)	Fuel Operated Air Heater	Operated Coolant Heater	Battery Managemen t Start/Stop	APU (Diesel)	APU (Battery)	(Battery) & Fuel Operated Air	(Battery) & Battery Managemen	Truck Stop Electrification - Single System	Shore Power
Annual Idling Petroleum Use Externality Costs											
LD Petroleum Use	$1,716		$1,215	$1,716	$1,334		$1,278	$777	$875		
HD Petroleum Use		$6,802	$4,709	$6,802	$4,736	$1,528	$4,368	$2,276	$2,731	$2,554	$2,554
Annual Idling GHG Externality Costs											
LD GHGs	$2,402		$1,701	$2,402	$1,867		$1,789	$1,088	$1,225		
HD GHGs		$9,279	$6,425	$9,279	$6,461	$2,085	$5,959	$3,104	$3,726	$3,703	$3,703
Annual Idling Air Pollutant Externality Costs											
LD Passenger Car Fleet											
CO	$0		$0	$0	$0		$0	$0	$0		
NOx	$1		$7	$1	$1		$1	$6	$0		
PM10	$2		$3	$2	$2		$2	$2	$1		
PM2.5	$21		$26	$21	$15		$15	$20	$7		
VOC	$0		$3	$0	$0		$0	$2	$0		
SOx	$92		$65	$92	$71		$68	$42	$47		
Light-Duty Total	$117		$103	$117	$89		$86	$73	$55		
HD Combination Long-Haul Truck Fleet											
CO		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
NOx		$24	$17	$24	$16	$108	$15	$8	$8	$24	$24
PM10		$2	$7	$2	$1	$1,313	$1	$7	$1	$2	$2
PM2.5		$17	$14	$17	$11	$329	$10	$7	$6	$17	$17
VOC		$3	$15	$3	$2	$1,798	$2	$14	$1	$3	$3
SOx		$11	$10	$11	$8	$542	$7	$6	$5	$11	$11
Heavy-Duty Total		$58	$63	$58	$39	$4,090	$36	$41	$20	$58	$58
Total Petroleum, GHG, and Air Pollutant Externality Costs											
LD Fleet	$4,234		$3,019	$4,234	$3,290		$3,153	$1,938	$2,155		
HD Fleet		$16,139	$11,197	$16,139	$11,236	$7,703	$10,363	$5,421	$6,477	$6,315	$6,315
Total Petroleum, GHG, and Air Pollutant Cost Savings											
LD Fleet			$1,215	$0	$945		$1,081	$2,296	$2,079		
HD Fleet			$4,942	$0	$4,903	$8,436	$5,776	$10,718	$9,661	$9,824	$9,824
Annual Operating Savings with Externality Cost Savings											
Compared to Gasoline LD Fleet			$5,954		$3,789		$4,323	$10,277	$10,003		
Compared to Diesel HD Fleet			$14,572		$9,854	$32,938	$12,430	$27,002	$24,270	$27,807	$28,832
Simple Payback with Externality Costs (years)											
LD Passenger Car Fleet			**1.5**		**4.0**		**9.9**	**5.1**	**5.8**		
HD Single Unit Short-Haul Truck Fleet			**1.2**		**2.5**	**3.0**	**6.4**	**3.6**	**4.3**	**0.0**	**0.9**

Figure 35. IR Outputs Sheet – LDV Simple Payback with and without Externalities Graph

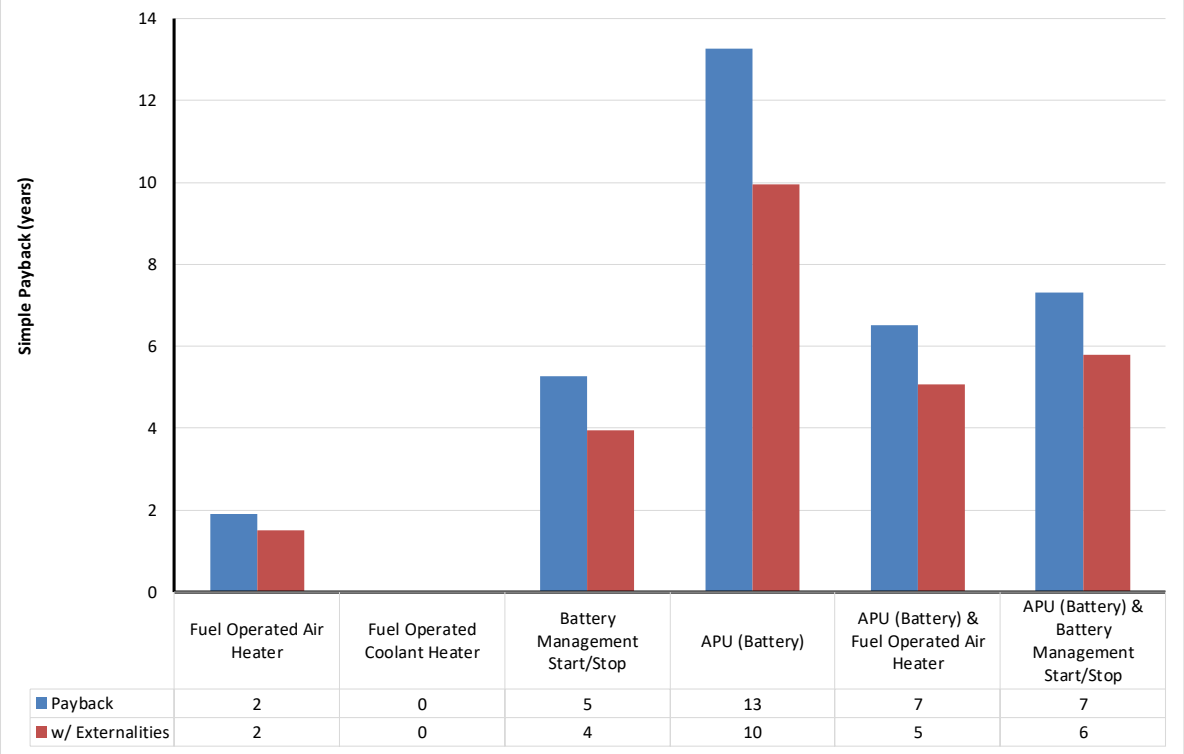
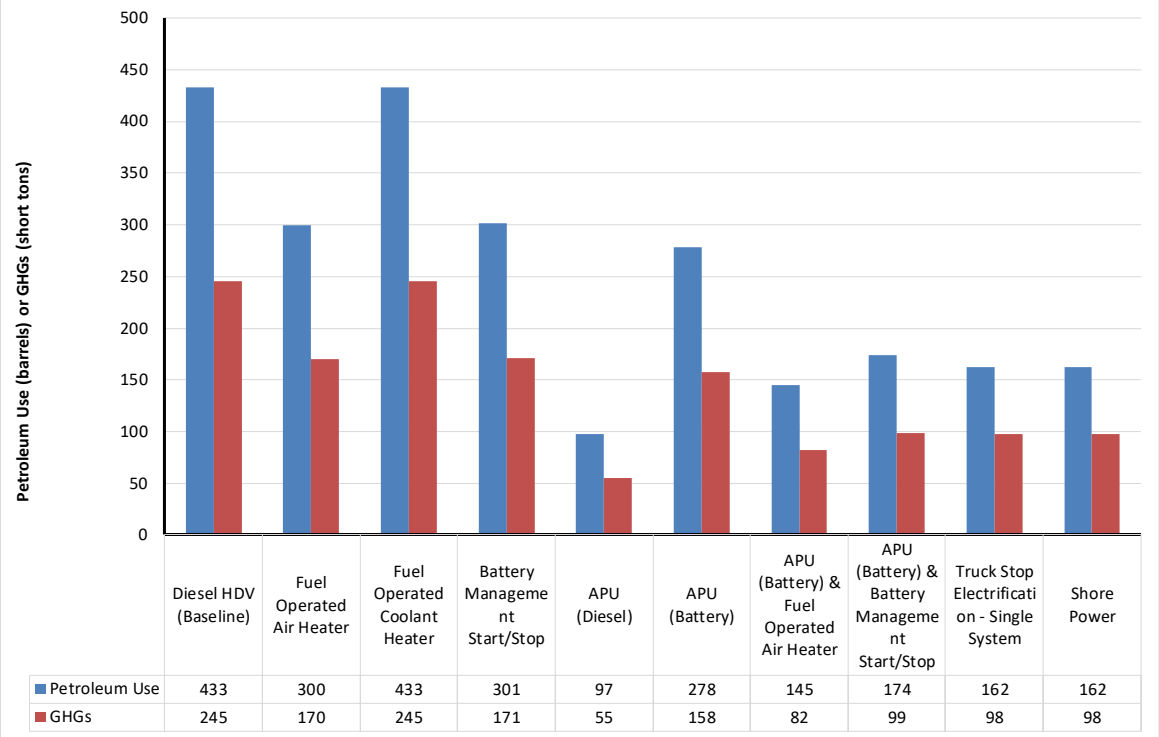
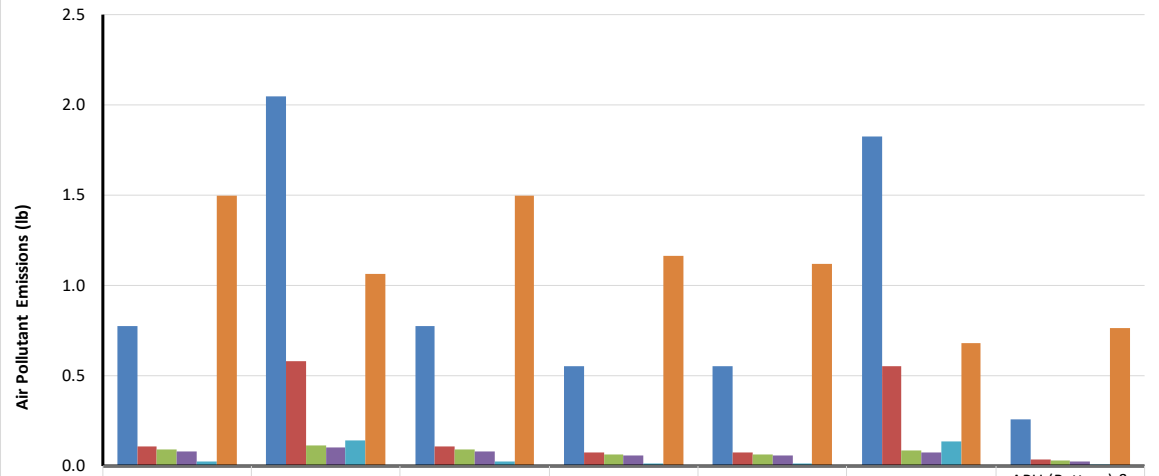


Figure 36. IR Outputs Sheet – Annual HDV Energy Use and GHGs Summary Graph



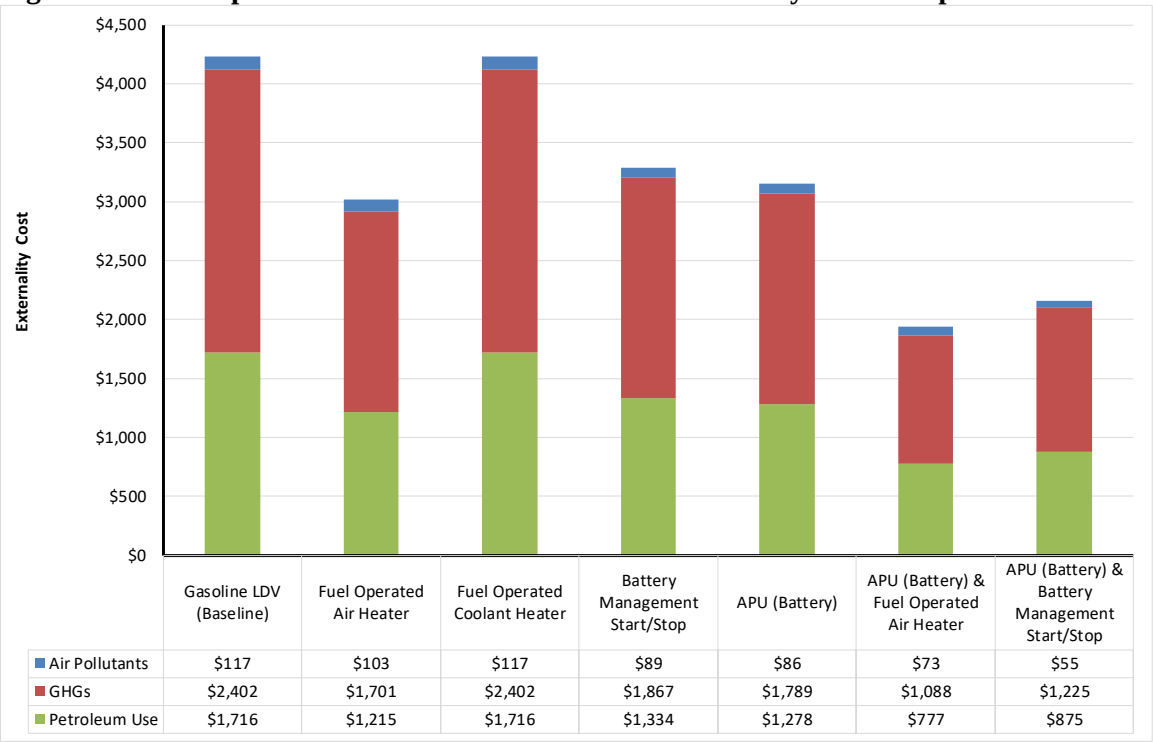
	Diesel HDV (Baseline)	Fuel Operated Air Heater	Fuel Operated Coolant Heater	Battery Management Start/Stop	APU (Diesel)	APU (Battery)	APU (Battery) & Fuel Operated Air Heater	APU (Battery) & Battery Management Start/Stop	Truck Stop Electrification - Single System	Shore Power
Petroleum Use	433	300	433	301	97	278	145	174	162	162
GHGs	245	170	245	171	55	158	82	99	98	98

Figure 37. IR Outputs Sheet – Annual LDV Air Pollutant Emissions Summary Graph



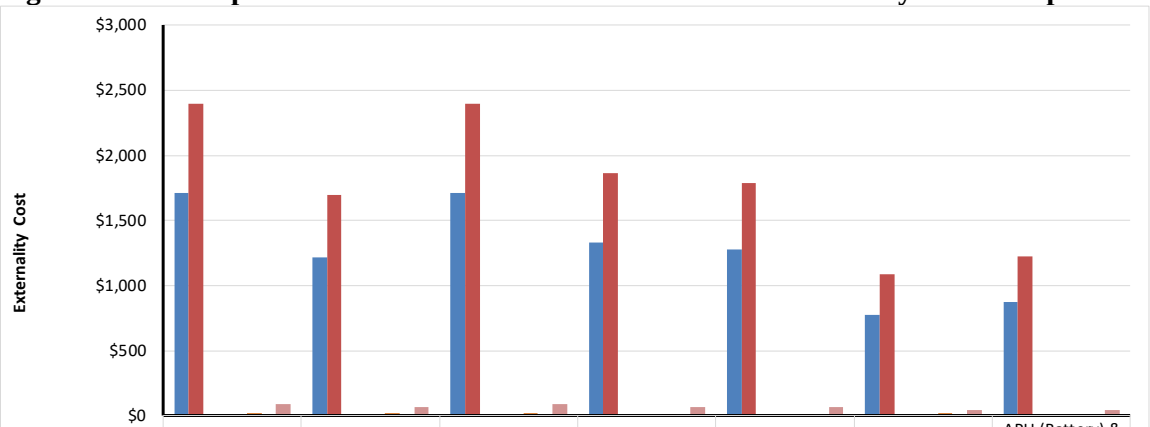
	Gasoline LDV (Baseline)	Fuel Operated Air Heater	Fuel Operated Coolant Heater	Battery Management Start/Stop	APU (Battery)	APU (Battery) & Fuel Operated Air Heater	APU (Battery) & Battery Management Start/Stop
CO	0.8	2.0	0.8	0.6	0.6	1.8	0.3
NOx	0.1	0.6	0.1	0.1	0.1	0.6	0.0
PM10	0.1	0.1	0.1	0.1	0.1	0.1	0.0
PM2.5	0.1	0.1	0.1	0.1	0.1	0.1	0.0
VOC	0.0	0.1	0.0	0.0	0.0	0.1	0.0
SOx	1.5	1.1	1.5	1.2	1.1	0.7	0.8

Figure 38. IR Outputs Sheet – Annual HDV Annual Externality Costs Graph



	Gasoline LDV (Baseline)	Fuel Operated Air Heater	Fuel Operated Coolant Heater	Battery Management Start/Stop	APU (Battery)	APU (Battery) & Fuel Operated Air Heater	APU (Battery) & Battery Management Start/Stop
Air Pollutants	$117	$103	$117	$89	$86	$73	$55
GHGs	$2,402	$1,701	$2,402	$1,867	$1,789	$1,088	$1,225
Petroleum Use	$1,716	$1,215	$1,716	$1,334	$1,278	$777	$875

Figure 39. IR Outputs Sheet – Annual LDV Annual Detailed Externality Costs Graph



	Gasoline LDV (Baseline)	Fuel Operated Air Heater	Fuel Operated Coolant Heater	Battery Management Start/Stop	APU (Battery)	APU (Battery) & Fuel Operated Air Heater	APU (Battery) & Battery Management Start/Stop
Petroleum Use	$1,716	$1,215	$1,716	$1,334	$1,278	$777	$875
GHGs	$2,402	$1,701	$2,402	$1,867	$1,789	$1,088	$1,225
CO	$0	$0	$0	$0	$0	$0	$0
NOx	$1	$7	$1	$1	$1	$6	$0
PM10	$2	$3	$2	$2	$2	$2	$1
PM2.5	$21	$26	$21	$15	$15	$20	$7
VOC	$0	$3	$0	$0	$0	$2	$0
SOx	$92	$65	$92	$71	$68	$42	$47

2.9 Footprint Sheet

This sheet contains the Fleet Footprint Calculator, which estimates the current year and remaining lifetime 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 40) for this sheet are:

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

The user can change the vehicle types via dropdown box. The user then must enter a model year between 1988 and 2023, vehicle mileage, and fuel use to estimate its energy use, emissions, and externality costs (Figure 41) of existing fleet vehicles and vehicles planned to be purchased. If you want to estimate the remaining lifetime, the user can either can enter the remaining lifetime in this sheet or set a maximum lifetime by entering that number for both LDVs and HDVs on the Inputs sheet in the TCO Input section under “Years of Planned Ownership”. If the user would like to examine more vehicles than is provided in this sheet, the user can copy and paste the entire row(s) with calculations (rows 6-65 in AFLEET Tool 2018) below the existing rows.

Figure 40. Footprint Sheet - Inputs

State: ILLINOIS — Year: 2017

Vehicle Type	Model Year	Annual Vehicle Mileage	Fuel Use														Remaining Lifetime			
			Gasoline (gal)	Diesel (gal)	Electricity (kWh)	G.H2 (kg)	Diesel HEV (gal)	Diesel HHV (gal)	B20 (gal)	B100 (gal)	RD20 (gal)	RD100 (gal)	E85 (gal)	LPG (gal)	CNG (GGE)	LNG (gal)	Default Lifetime	Calculated Lifetime	Age	Remaining Lifetime
Passenger Car																	0	0	0	0
Light Commercial Truck																	0	0	0	0
Passenger Car																	0	0	0	0
Passenger Car																	0	0	0	0
Passenger Car																	0	0	0	0
Passenger Car																	0	0	0	0
Passenger Car																	0	0	0	0
Passenger Car																	0	0	0	0
Passenger Car																	0	0	0	0
Passenger Car																	0	0	0	0
Passenger Car																	0	0	0	0
Passenger Car																	0	0	0	0
Transit Bus																	0	0	0	0
Transit Bus																	0	0	0	0
Transit Bus																	0	0	0	0
Refuse Truck																	0	0	0	0
Refuse Truck																	0	0	0	0
Refuse Truck																	0	0	0	0
Single Unit Short-Haul Truck																	0	0	0	0
Single Unit Short-Haul Truck																	0	0	0	0
Single Unit Short-Haul Truck																	0	0	0	0
Single Unit Long-Haul Truck																	0	0	0	0
Single Unit Long-Haul Truck																	0	0	0	0
Single Unit Long-Haul Truck																	0	0	0	0
Combination Short-Haul Truck																	0	0	0	0
Combination Short-Haul Truck																	0	0	0	0
Combination Short-Haul Truck																	0	0	0	0
Combination Long-Haul Truck																	0	0	0	0
Combination Long-Haul Truck																	0	0	0	0
Combination Long-Haul Truck																	0	0	0	0

Figure 41. 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 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

2.10 Footprint Outputs Sheet

This sheet summarizes the outputs of the Fleet Footprint Calculator with a table and graphs for current year and remaining lifetime petroleum use, GHGs, air pollutant emissions, and externality costs of the entire fleet (Figures 42-46). 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 42. Footprint Outputs Sheet – Current Year 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 43. Footprint Outputs Sheet – Remaining Lifetime 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 44. Footprint Outputs Sheet – Current Year Fleet Energy Use and GHGs Summary Graph

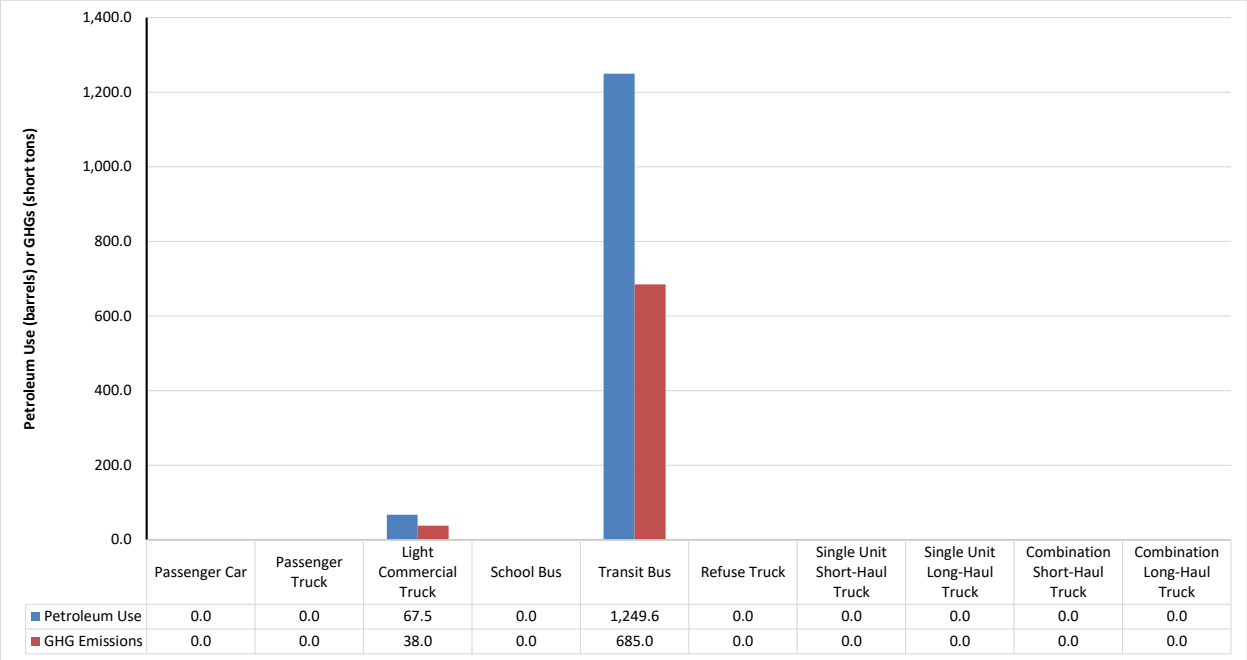
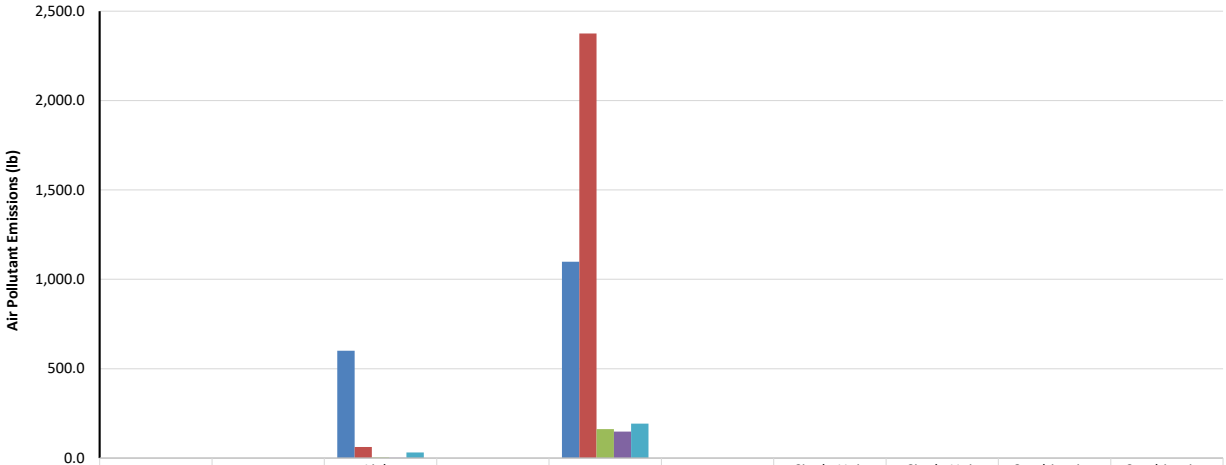
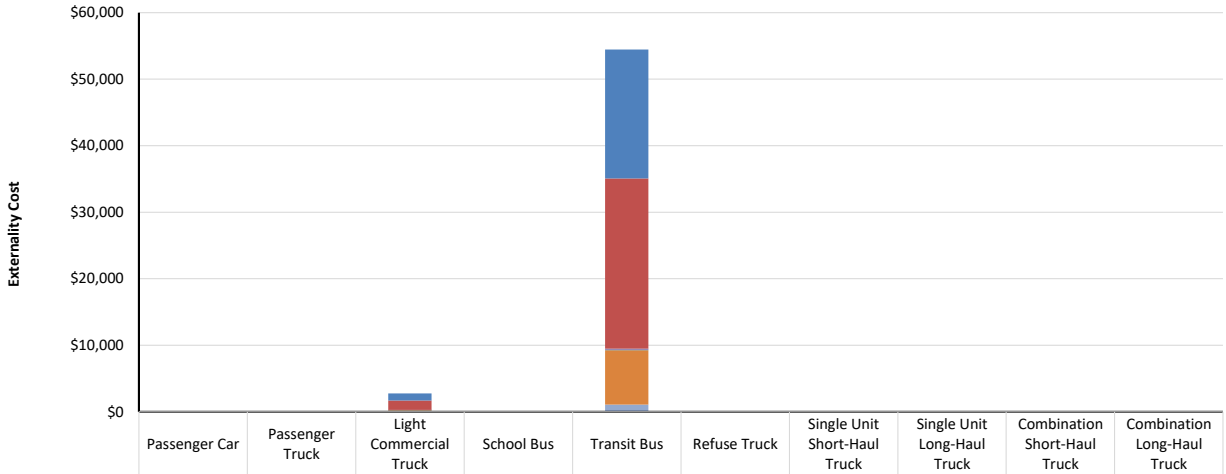


Figure 45. Footprint Outputs Sheet – Remaining Lifetime Fleet Air Pollutant Emissions Summary Graph



	Passenger Car	Passenger Truck	Light Commercial Truck	School Bus	Transit Bus	Refuse Truck	Single Unit Short-Haul Truck	Single Unit Long-Haul Truck	Combination Short-Haul Truck	Combination Long-Haul Truck
CO	0.0	0.0	600.9	0.0	1,098.1	0.0	0.0	0.0	0.0	0.0
NOx	0.0	0.0	62.5	0.0	2,375.1	0.0	0.0	0.0	0.0	0.0
PM10	0.0	0.0	4.0	0.0	161.9	0.0	0.0	0.0	0.0	0.0
PM2.5	0.0	0.0	1.7	0.0	148.4	0.0	0.0	0.0	0.0	0.0
VOC	0.0	0.0	32.0	0.0	193.3	0.0	0.0	0.0	0.0	0.0

Figure 46. Footprint Outputs Sheet – Current Year Fleet Air Pollutant Emissions Summary Graph



	Passenger Car	Passenger Truck	Light Commercial Truck	School Bus	Transit Bus	Refuse Truck	Single Unit Short-Haul Truck	Single Unit Long-Haul Truck	Combination Short-Haul Truck	Combination Long-Haul Truck
Petroleum Use	$0	$0	$1,047	$0	$19,397	$0	$0	$0	$0	$0
GHG Emissions	$0	$0	$1,420	$0	$25,577	$0	$0	$0	$0	$0
CO	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
NOx	$0	$0	$4	$0	$157	$0	$0	$0	$0	$0
PM10	$0	$0	$14	$0	$82	$0	$0	$0	$0	$0
PM2.5	$0	$0	$91	$0	$8,172	$0	$0	$0	$0	$0
VOC	$0	$0	$179	$0	$1,078	$0	$0	$0	$0	$0

2.11 Background Data Sheet

This sheet contains the background data for the Simple Payback, Total Cost of Ownership, Idle Reduction, and Fleet 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 for both the Payback/TCO AFVs (Figure 47) and the IR equipment. This will alter the lookup tables, which AFLEET Tool references for the default data of key inputs in the various sheets. Figure 48 shows an example of one look up table. Also mentioned previously, the user can input custom electricity mixes on this sheet (Figure 49). 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 47. 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 48. Background Data Sheet - AFLEET Look Up Tables - New Vehicle Purchase Price

Vocation Type	MOVES Category	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)	Diesel Hybrid Electric Vehicle (HEV)	Diesel Hydraulic Hybrid (HHV)	Biodiesel (B20)	Biodiesel (B100)	Ethanol (E85)	Propane (LPG)	Compressed Natural Gas (CNG)	Liquefied Natural Gas (LNG)	LNG / Diesel Pilot Ignition
Long Haul Freight Truck	Combination Long-Haul Truck		$100,000						$140,000		$100,000	$100,000			$165,000	$150,000	$190,000
Regional Haul Freight Truck	Combination Short-Haul Truck		$90,000						$137,500		$90,000	$90,000			$130,000	$120,000	$155,000
Delivery Straight Truck	Single Unit Long-Haul Truck		$75,000						$115,000		$75,000	$75,000			$140,000	$125,000	
Delivery Step Van	Single Unit Short-Haul Truck		$65,000				$150,000		$105,000		$65,000	$65,000			$105,000	$95,000	
Dump Truck			$80,000								$80,000	$80,000			$140,000	$130,000	
Bucket/Aerial Truck			$155,000				$355,000				$155,000	$155,000			$215,000	$205,000	
Snow Plow/Sander			$100,000								$100,000	$100,000			$170,000	$160,000	
Sewer Cleaner			$385,000								$385,000	$385,000			$410,000	$410,000	
Street Sweeper			$190,000								$190,000	$190,000			$265,000		
Refuse Truck	Refuse Truck		$210,000				$670,000		$260,000	$250,000	$210,000	$210,000			$260,000	$250,000	
Transit Bus	Transit Bus		$300,000				$750,000	$1,800,000	$510,000		$300,000	$300,000			$360,000	$350,000	
School Bus	School Bus		$90,000						$150,000		$90,000	$90,000		$105,000	$140,000	$130,000	
Shuttle/Paratransit Bus			$65,000						$120,000		$65,000	$65,000		$75,000	$90,000		
Medium-Duty Pickup Truck	Light Commercial Truck	$36,000	$46,500								$46,500	$46,500	$36,000	$44,000	$48,500		
Utility Cargo Van		$34,500	$46,500				$69,500				$46,500	$46,500	$34,500	$42,500	$50,500		
Shuttle/Paratransit Van		$38,000	$50,000								$50,000	$50,000	$38,000	$44,500	$48,000		
Light-Duty Pickup Truck	Passenger Truck	$32,000	$39,500								$39,500	$39,500	$32,000	$38,500	$43,500		
SUV		$27,500	$30,000	$31,500			$59,000	$66,000			$30,000	$30,000	$27,500	$33,500	$40,000		
SUV - Taxi		$27,500	$30,000	$31,500			$59,000	$66,000			$30,000	$30,000	$27,500	$33,500	$40,000		
Car	Passenger Car	$20,000	$22,500	$23,000	$32,500	$34,000	$30,000	$58,500			$22,500	$22,500	$20,000	$26,000	$27,000		
Car - Taxi		$20,000	$22,500	$23,000	$32,500	$34,000	$30,000	$58,500			$22,500	$22,500	$20,000	$26,000	$27,000		
Car - Police		$20,000	$22,500	$23,000	$32,500	$34,000	$30,000	$58,500			$22,500	$22,500	$20,000	$26,000	$27,000		
Maintenance Utility Vehicle		$14,000					$19,000				$0	$0	$14,000				
Other																	

Figure 49. Background Data Sheet – GREET Fleet Specifications – Electricity Mix

	U.S. Average 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	0.6%	12.6%	1.7%	70.3%	0.2%	1.4%	0.2%	0.4%	1.3%	0.1%	0.2%	0.6%
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%	12.2%	28.7%	28.3%	27.3%	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%

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