

# **User Guide for AFLEET Tool 2020**

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By:  
Andrew Burnham  
Systems Assessment Center  
Energy Systems Division, Argonne National Laboratory

April 2021



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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, Barron McHenry, Andrew Jin, Krystal Krygowski, Shannon O'Donnell, Madalyn Seveska, Sandra Marquez, Bode Hoover, and Eric Pfister 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.H <sub>2</sub>	gaseous hydrogen
GHG	greenhouse gas
REET	Greenhouse gases, Regulated Emissions, and Energy Use in Transportation
HDV	heavy-duty vehicle
HEV	hybrid electric vehicle
HHV	hydraulic hybrid vehicle
IR	idle reduction
LDV	light-duty vehicle
LNG	liquefied natural gas
LPG	liquefied petroleum gas
MOVES	Motor Vehicle Emission Simulator
NO <sub>x</sub>	nitrogen oxides

PHEV	plug-in hybrid electric vehicle
PM <sub>10</sub>	particulate matter with a diameter of 10 micrometers or less
PM <sub>2.5</sub>	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 <sub>x</sub>	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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Andrew Burnham

Systems Assessment Center  
Argonne National Laboratory

April 2021

## 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 six 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 either a new on-road or new off-road 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 On-Road Fleet Footprint Calculator estimates the annual petroleum use, GHGs, and air pollutant emissions of existing and new on-road vehicles, taking into consideration that older vehicles typically have higher air pollutant emission rates than newer ones. The fourth option is the Off-Road Fleet Footprint Calculator estimates the annual petroleum use, GHGs, and air pollutant emissions of existing and new off-road equipment, taking into consideration that older equipment typically have higher air pollutant emission rates

than newer ones. The fifth option is the Electric Vehicle Charging Calculator estimates the annual petroleum use, GHGs, and air pollutant benefits of utilizing public electric vehicle charging infrastructure. 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 fifteen Microsoft® Excel sheets in the calculator, which are explained below.

### 2.1 Intro 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. Intro Sheet – Cell Color Scheme**

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

### 2.2 Inputs Sheet

The essential user inputs (Figure 2) for both the Simple Payback and Total Cost of Ownership calculators are shared between these two calculators and are located on the Inputs sheet. In addition, On-Road Fleet Footprint, Off-Road Fleet Footprint, Electric Vehicle Charging, and Idle Reduction Calculators use the vehicle location for air pollutant calculations, while 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**
- **vehicle maintenance cost**
- **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. 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). Users need to enter 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)	Maintenance & Repair (\$/mi)
Gasoline	0	12,400	30.9	\$20,000	\$0.15
Diesel	0	12,400	37.1	\$27,000	\$0.23
Gasoline Hybrid Electric Vehicle (HEV)	0	12,400	46.3	\$22,000	\$0.14
Gasoline Plug-in Hybrid Electric Vehicle (PHEV)	0	12,400	53.2	\$27,000	\$0.13
Gasoline Extended Range Electric Vehicle (EREV)	0	12,400	44.4	\$33,000	\$0.13
All-Electric Vehicle (EV)	0	12,400	106.2	\$37,000	\$0.09
Gaseous Hydrogen (G.H2) Fuel Cell Vehicle (FCV)	0	12,400	73.5	\$50,000	\$0.09
Biodiesel (B20)	0	12,400	37.1	\$27,000	\$0.23
Biodiesel (B100)	0	12,400	37.1	\$27,000	\$0.23
Renewable Diesel (RD20)	0	12,400	37.1	\$27,000	\$0.23
Renewable Diesel (RD100)	0	12,400	37.1	\$27,000	\$0.23
Ethanol (E85)	0	12,400	30.9	\$20,000	\$0.15
Propane (LPG)	0	12,400	30.9	\$26,000	\$0.15
Compressed Natural Gas (CNG)	0	12,400	29.4	\$27,000	\$0.15
Heavy-Duty Vehicle Information					
Vehicle Type	School Bus				
Vocation Type	School Bus				
Heavy-Duty Fuel Type	Number of Heavy-Duty Vehicles	Annual Vehicle Mileage	Fuel Economy (MPDGE)	Purchase Price (\$/vehicle)	Maintenance & Repair (\$/mi)
Gasoline	0	0	6.8	\$0	\$0.61
Diesel	0	15,000	8.2	\$100,000	\$0.93
All-Electric Vehicle (EV)	0	15,000	24.0	\$300,000	\$0.56
Gaseous Hydrogen (G.H2) Fuel Cell Vehicle (FCV)	0	0	11.3	\$0	\$0.56
Diesel Hybrid Electric Vehicle (HEV)	0	15,000	11.1	\$160,000	\$0.81
Diesel Hydraulic Hybrid (HHV)	0	0	10.6	\$0	\$0.81
Biodiesel (B20)	0	15,000	8.2	\$100,000	\$0.93
Biodiesel (B100)	0	15,000	8.2	\$100,000	\$0.93
Renewable Diesel (RD20)	0	15,000	8.2	\$100,000	\$0.93
Renewable Diesel (RD100)	0	15,000	8.2	\$100,000	\$0.93
Ethanol (E85)	0	0	6.8	\$0	\$0.61
Propane (LPG)	0	15,000	6.8	\$108,000	\$0.61
Compressed Natural Gas (CNG)	0	15,000	7.0	\$130,000	\$0.93
Liquefied Natural Gas (LNG)	0	15,000	7.0	\$120,000	\$0.93
LNG / Diesel Pilot Ignition	0	0	7.8	\$0	\$0.97
Refueling Information					
Fueling Type	Private Station	Infrastructure costs (go to 'Payback')			
Fuel Price Sensitivity	No	Enter fuel price range (go to 'Payback')			
Fuel and DEF Price					
		Public Station	Private Station		
Fuel Unit		(\$/fuel unit)			
Gasoline	gasoline gallon	\$2.53	\$2.29		
Diesel	diesel gallon	\$2.68	\$1.95		
Electricity	kWh	\$0.13	\$0.13		
G.H2	hydrogen kg	\$12.18			
B20	B20 gallon	\$2.90	\$2.48		
B100	B100 gallon	\$3.62	\$3.25		
RD20	RD20 gallon				
RD100	RD100 gallon				
E85	E85 gallon	\$2.24	\$2.20		
Propane	LPG gallon	\$3.05	\$1.49		
CNG	CNG GGE	\$2.51	\$1.78		
LNG	LNG gallon	\$1.75	\$1.10		
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 2020). 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

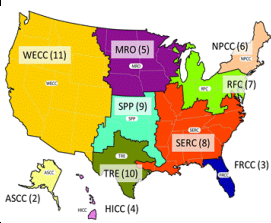
**Figure 3. Inputs Sheet - Total Cost of Ownership Inputs**

Vehicle and Infrastructure Information				
		Light-Duty Vehicle	Heavy-Duty Vehicle	Infrastructure
Years of Planned Ownership	years	15	15	15
Financial Assumptions				
		Light-Duty Vehicle	Heavy-Duty Vehicle	Infrastructure
Loan	yes/no	No	No	No
Loan Term	years	5	5	5
Interest Rate	%	4.20%	4.20%	4.20%
Percent Down Payment	%	12.00%	12.00%	12.00%
Discount Factor	%		1.24%	

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 2 - Canola 3 - Corn 4 - Tallow	1
Renewable Diesel Feedstock Source	1 - Soy 2 - Tallow 3 - Palm	1
Ethanol Feedstock Source	1 - Corn 2 - Switchgrass 3 - Sugarcane 4 - Grain Sorghum	1
CNG Feedstock Source	1 - North American NG 2 - Landfill Gas 3 - AD Gas of Animal Waste 4 - AD Gas of Wastewater Sludge 5 - AD Gas of MSW	1
LNG Feedstock Source	1 - North American NG 2 - Landfill Gas 3 - AD Gas of Animal Waste 4 - AD Gas of Wastewater Sludge 5 - AD Gas of MSW	1
North American NG Feedstock Source	Conventional 66%	Shale 34%
LPG Feedstock Source	NG 69%	Petroleum 31%
Source of Electricity for PHEVs, EVs, and FCVs (Electrolysis)	1 - Average U.S. Mix 2 to 11 - EIA Region Mix (see map) <a href="#">12 - User Defined (go to 'Background Data' sheet)</a>	7
G.H2 Production Process	1 - Refueling Station SMR (On-site) 2 - Central Plant SMR (Off-site) 3 - Refueling Station Electrolysis (On-site)	1



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 2020a). 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 2020b). 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 2020’s PHEV, EREV, and EV, respectively. AFLEET has the option to analyze GREET EV100 results. For AFLEET 2019, 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		3
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, LNG, LPG 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 2020a). In addition, sulfur oxides (SO<sub>x</sub>) 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<sub>x</sub> emissions for vehicle operation, upstream, and vehicle production are all calculated using GREET co-efficients. MOVES is not used for vehicle operation SO<sub>x</sub>, as these emissions can be calculated via a sulfur balance, i.e. amount of sulfur in the fuel directly impacts SO<sub>x</sub> emissions.

Recent analyses have found that diesel in-use emissions are much higher than their laboratory certification results (Cai 2017, Anenberg 2017). Diesel NO<sub>x</sub> 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<sub>x</sub> (Cai 2017). While data for in-use NO<sub>x</sub> of new diesels is limited, but analyses have shown that the MOVES2014 model was underestimating diesel NO<sub>x</sub> (Anenberg 2017, Sandhu 2017). In AFLEET 2019 and previous versions, 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). In 2020, EPA released a new version of MOVES (MOVES3) updating HDV diesel NO<sub>x</sub>, however they did not examine LDV diesel NO<sub>x</sub> (EPA 2020). Therefore in AFLEET 2020, the diesel in-use multiplier is 5.0 for diesel LDVs (Anenberg 2017), but no longer is applied to HDVs.

Also previously added, was a low-NO<sub>x</sub> 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. For AFLEET 2019, propane low-NOx vehicles were added to the natural gas vehicles, which have demonstrated the in-use performance (Ryskamp 2020, 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).

The next section on Inputs is for 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								
Annual Idling Hours (per Vehicle)	1750	Services Required (% of hours):							
% of Idle Hours by Service		33%	0%	33%	34%				
		<input checked="" type="checkbox"/> Vehicle Heating	<input checked="" type="checkbox"/> Engine Heating	<input checked="" type="checkbox"/> Cooling	<input checked="" type="checkbox"/> Electrical				
						Idling Hour	Fuel	Electrical	IR Equipment
						Reduction	Consumption	Power	Price
						Goal	(GGE/hr)	Demand (W)	(\$/Vehicle)
Light-Duty Baseline & IR Equipment									
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								
Annual Conventional Idling Hours (per Vehicle)	200	Services Required (% of hours):							
% of Idle Hours by Service		33%	0%	33%	34%				
		<input checked="" type="checkbox"/> Vehicle Heating	<input checked="" type="checkbox"/> Engine Heating	<input checked="" type="checkbox"/> Cooling	<input checked="" type="checkbox"/> Electrical				
Annual Hotelling Hours (per Vehicle)*	0	Services Required (% of hours):							
% of Hotelling Hours by Service		33%	0%	33%	34%				
		<input checked="" type="checkbox"/> Vehicle Heating	<input checked="" type="checkbox"/> Engine Heating	<input checked="" type="checkbox"/> Cooling	<input checked="" type="checkbox"/> Electrical				
						Conventional	Hotelling	Fuel	Electrical
						Idling Hour	Hour	Consumption	Power
						Reduction	Reduction	(DGE/hr)	Demand (W)
						Goal	Goal		(\$/Vehicle)
Heavy-Duty Baseline & IR Equipment									
Diesel	1							0.75	
Diesel (Hotelling)*								0.00	
Fuel Operated Air Heater	1					66	0	0.06	0
Fuel Operated Coolant Heater	1					0	0	0.12	0
Battery Management Start/Stop	1					68	0	0.00	1,300
APU (Diesel)	1					200	0	0.20	0
APU (Battery)	1					134	0	0.00	1,300
APU (Battery) & Fuel Operated Air Heater	1					200	0	0.06	1,300
APU (Battery) & Battery Management Start/Stop	1					134	0	0.00	1,300
Truck Stop Electrification - Single System	1					134	0	0.00	0
Shore Power	1					134	0	0.00	1,300

Argonne has provided default data for many inputs in AFLEET Tool; however, it is highly recommended that users enter their own data whenever possible. 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.**

For AFLEET 2019, Electric Vehicle Charging Calculator was added. The essential user inputs (Figure 7), in addition to those mentioned previously (vehicle location) are:

- **number of chargers**
- **weekly station utilization**
- **average session power**
- **charge time.**

**Figure 7. Inputs Sheet – Electric Vehicle Charging Inputs**

<b>Level 2 Charging Infrastructure</b>				
Predicted Weekly Utilization	Moderate			
Venue	Number of Chargers	Weekly Utilization (sessions/week/ station)	Average Session Power (kW)	Charge Time (minutes/ session)
Parking Lot	1	4.5	4	150
Retail & Leisure	1	5.5	4	90
Education	1	6.0	4	150
Healthcare	1	6.5	4	150
Workplace	1	4.5	4	150
Multi-Unit Dwelling	1	3.0	4	210
Single-Unit Dwelling	1	6.0	4	120
<b>DC Fast Charging Infrastructure</b>				
Predicted Weekly Utilization	Moderate			
Venue	Number of Chargers	Weekly Utilization (sessions/week/ station)	Average Session Power (kW)	Charge Time (minutes/ session)
Parking Lot	1	15.0	24	22
Retail & Leisure	1	15.0	24	22
Education	1	15.0	24	22
Healthcare	1	15.0	24	22
Workplace	1	15.0	24	22
Multi-Unit Dwelling	1	15.0	24	22
Single-Unit Dwelling	1	15.0	24	22

Argonne has provided default data for many inputs in AFLEET Tool; however, it is highly recommended that users enter their own data whenever possible. The user must enter the number of chargers to be analyzed as the default is set to zero. The Electric Vehicle Charging Calculator estimates the annual petroleum use, GHGs, and air pollutant benefits of utilizing public electric vehicle level 2 and DC fast charging infrastructure. Unlike other calculators in AFLEET, the Electric Vehicle Charging Calculator output is the benefit of utilizing a charger and not actual emission impacts of the charger.

The benefit is calculated by the user entering utilization for each charger type, we provide default weekly utilization, average session power and charge time. As seen in Figure 7, a “moderate” level of weekly utilization is provided by default for both level 2 and DC fast chargers by venue type, but the user can change to “low” or “high” levels of utilization by using the dropdown box. The data for these defaults are based on several sources including Chicago, New York State, Columbus, Austin, Seattle, and numerous locations from the EV Project (Mintz 2018, Ruder 2019, Wood 2018, EV Project 2013). The focus of the Calculator is to look at public chargers; however, single unit dwellings are included for comparison purposes. The same types of venues are included for both level 2 and DC fast chargers for consistency. The venue types in AFLEET are:

- **parking lot**
- **retail & leisure**
- **education**
- **healthcare**
- **workplace**
- **multi-unit dwelling**
- **single-unit dwelling.**

The utilization data is used to calculate the electricity dispensed by each charger. The amount of EV miles is estimated using a weighted EV efficiency and the amount of electricity dispensed. The energy use and emissions are then estimated for the EV mileage dispensed by the chargers. A counterfactual, of those miles driven by a gasoline vehicle instead of an EV is used to estimate the baseline emissions. Therefore the energy and emissions are estimated for a gasoline vehicle driving the same mileage as dispensed by EV chargers. The EV charging benefit is equal to the EV emissions subtracted from gasoline emissions.

For AFLEET 2020, off-road equipment was added to the Simple Payback Calculator. The essential user inputs (Figure 8), in addition to those mentioned previously (vehicle location and fuel price) are:

- **equipment type**
- **rated horsepower**
- **EV battery type, replacements per lifetime, capacity, and cost**
- **equipment fuel type**
- **number of units**
- **annual hourly usage**
- **fuel consumption**
- **equipment purchase price**
- **equipment maintenance cost.**

The 21 equipment types in AFLEET 2020 are based on the EPA MOVES3 (NONROAD) and are separated into small equipment and large equipment. For small equipment types, gasoline fuel is the baseline and the engine sizes are typically less than 25 horsepower. For large equipment types, diesel fuel is the baseline and the engine sizes are larger than 25 horsepower. The equipment can be further grouped into six categories: agricultural, airport support, construction, industrial, lawn & garden, and recreational:

**Small Equipment:**

**Industrial**

- sweepers/scrubbers

**Lawn & Garden**

- chain saws
- commercial turf equipment
- lawn & garden tractors
- lawn mowers
- leafblowers/vacuums
- snowblowers
- trimmers/edgers/brush cutter

**Recreational**

- golf carts

**Large Equipment:**

**Agricultural**

- agricultural tractors

**Airport Support**

- airport support equipment

**Construction**

- cranes
- crawler tractor/dozers
- excavators
- rollers
- rubber tire loaders
- skid steer loaders
- tractors/loaders/backhoes

**Industrial**

- aerial lifts
- forklifts
- sweepers/scrubbers
- terminal tractors

**Figure 8. Inputs Sheet – Off-Road Equipment Inputs**

Small Equipment Information					
Equipment Type	Commercial Turf Equipment				
Vocation Type	Zero-Turn Commercial Turf				
Rated Horsepower	25				
	Type	Replacements per Lifetime	Battery Capacity (kWh)	Battery Cost (\$/kWh)	Lifetime Replacement Cost
EV Battery Replacement	Lithium-Ion	0	21.6	\$800	\$0
Small Equipment Fuel Type	Number of Units	Annual Hourly Usage	Fuel Consumption (GGE/hr)	Equipment Price (\$/unit)	Maintenance & Repair (\$/hr)
Gasoline	0	1,364	0.34	\$12,000	\$0.12
Diesel	0	1,364	0.28	\$16,000	\$0.15
Gasoline Hybrid Electric	0	0	0.24	\$0	\$0.00
All-Electric Vehicle (EV)	0	1,364	0.07	\$23,000	\$0.05
Gaseous Hydrogen (G.H2)	0	0	0.11	\$0	\$0.00
Biodiesel (B20)	0	0	0.28	\$0	\$0.00
Biodiesel (B100)	0	0	0.28	\$0	\$0.00
Renewable Diesel (RD20)	0	0	0.28	\$0	\$0.00
Renewable Diesel (RD100)	0	0	0.28	\$0	\$0.00
Ethanol (E85)	0	0	0.34	\$0	\$0.00
Propane (LPG)	0	1,364	0.34	\$13,500	\$0.12
(CNG)	0	0	0.34	\$0	\$0.00
Large Equipment Information					
Equipment Type	Forklifts				
Vocation Type	Warehouse Forklift				
Rated Horsepower	50				
	Type	Replacements per Lifetime	Battery Capacity (kWh)	Battery Cost (\$/kWh)	Lifetime Replacement Cost
EV Battery Replacement	Lead-Acid	0	43.2	\$200	\$0
Large Equipment Fuel Type	Number of Units	Annual Hourly Usage	Fuel Consumption (DGE/hr)	Equipment Price (\$/unit)	Maintenance & Repair (\$/hr)
Gasoline	0	1,700	0.70	\$22,000	\$0.14
Diesel	0	1,700	0.58	\$30,000	\$0.19
All-Electric Vehicle (EV)	0	1,700	0.14	\$37,000	\$0.08
Gaseous Hydrogen (G.H2)	0	1,700	0.23	\$40,000	\$0.08
Diesel Hybrid Electric	0	0	0.48	\$0	\$0.00
Diesel Hydraulic Hybrid	0	0	0.48	\$0	\$0.00
Biodiesel (B20)	0	0	0.58	\$0	\$0.00
Biodiesel (B100)	0	0	0.58	\$0	\$0.00
Renewable Diesel (RD20)	0	0	0.58	\$0	\$0.00
Renewable Diesel (RD100)	0	0	0.58	\$0	\$0.00
Ethanol (E85)	0	0	0.70	\$0	\$0.00
Propane (LPG)	0	1,700	0.70	\$25,000	\$0.14
Compressed Natural Gas	0	1,700	0.70	\$50,000	\$0.14
Liquefied Natural Gas (LNG)	0	0	0.70	\$0	\$0.00
LNG / Diesel Pilot Ignition	0	0	0.58	\$0	\$0.00

Argonne has provided default data for many inputs in AFLEET Tool; however, it is highly recommended that users enter their own data whenever possible. The user must enter the number of units to be analyzed as the default is set to zero. The Simple Payback Calculator that examines acquisition and annual operating costs to calculate a simple payback for purchasing a

new off-road AFV as compared to its conventional counterpart, as well as average annual petroleum use, GHGs, and air pollutant emissions.

## 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<sub>x</sub>)** from tailpipe
- **particulate matter with a diameter of 10 micrometers or less (PM<sub>10</sub>)** from tailpipe and tire and brake wear (TBW)
- **particulate matter with a diameter of 2.5 micrometers or less (PM<sub>2.5</sub>)** from tailpipe and TBW
- **VOCs (volatile organic compounds)** from tailpipe and evaporation
- **Sulfur oxides (SO<sub>x</sub>)** from tailpipe

Key assumptions for light-duty vehicles, heavy-duty vehicles, small equipment, large equipment, and fuel price from the Inputs sheet are fed into the first three tables in the Payback sheet (Figure 9). 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 9. 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	RD20	RD100	E85	LPG	CNG	LNG / Diesel LNG Pilot Ignition
<b>On-Road Vehicle Inputs</b>																	
<b>Light-Duty Vehicle Inputs</b>																	
Vehicle Type	Passenger Car																
Number of LDVs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Mileage	12,400	12,400	12,400	12,400	12,400	12,400	12,400	12,400	12,400	12,400	12,400	12,400	12,400	12,400	12,400	12,400	12,400
Fuel Economy (MPGGE)	30.9	37.1	46.3	53.7	44.4	106.2	73.5			37.1	37.1	37.1	37.1	30.9	30.9	29.4	
CD Electricity Use (kWh/100mi)				25.3	34.5	31.0											
CD Electricity Use (GGE/100mi)				0.8	1.0												
CD Gasoline Use (GGE/100mi)				0.9	0.0												
PHEV CD Range (miles)				23.2	46.0												
Charges/day				1.0	1.0												
Days driven/week				5	5												
Share of CD miles				49%	97%												
Share of Alternative Fuel Use in Dual-Fuel or PHEV (Energy %)				21%	93%												
DEF Use (% of fuel consumption)	0%	2%	0%	0%	0%	0%	0%			2%	2%	2%	2%	0%	0%	0%	0%
Purchase Price (\$/vehicle)	\$20,000	\$27,000	\$22,000	\$27,000	\$33,000	\$37,000	\$50,000			\$27,000	\$27,000	\$27,000	\$27,000	\$20,000	\$26,000	\$27,000	
Incentive (\$/vehicle)	\$0	\$0	\$0	\$0	\$0	\$0	\$0			\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Maintenance & Repair (\$/mile)	\$0.150	\$0.228	\$0.137	\$0.131	\$0.131	\$0.095	\$0.095			\$0.228	\$0.228	\$0.228	\$0.228	\$0.150	\$0.150	\$0.150	
<b>Heavy-Duty Vehicle Inputs</b>																	
Vehicle Type	School Bus																
Number of HDVs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Mileage	0	15,000				15,000	0	15,000	0	15,000	15,000	15,000	15,000	0	15,000	15,000	15,000
Fuel Economy (MPGGE)	5.9	7.1				20.8	9.8	9.6	9.2	7.1	7.1	7.1	7.1	5.9	5.9	6.0	6.7
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%	2%	2%	0%	0%	0%	2%
Purchase Price (\$/vehicle)	\$0	\$100,000				\$300,000	\$0	\$160,000	\$0	\$100,000	\$100,000	\$100,000	\$100,000	\$0	\$108,000	\$130,000	\$120,000
Incentive (\$/vehicle)	\$0	\$0				\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Maintenance & Repair (\$/mile)	\$0.614	\$0.935				\$0.561	\$0.561	\$0.813	\$0.813	\$0.935	\$0.935	\$0.935	\$0.935	\$0.614	\$0.614	\$0.935	\$0.966
<b>Small Equipment Inputs</b>																	
Off-Road Small Equipment Type	Commercial Turf Equipment																
Number of Small Equipment Units	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Hourly Usage	1,364	1,364	0			1,364	0			0	0	0	0	0	1,364	0	0
Rated Horsepower	25	25	25			25	25			25	25	25	25	25	25	25	25
Load Factor %	60%	50%	43%			12%	20%			50%	50%	50%	50%	60%	60%	60%	
Fuel Consumption (GGE/hr)	0.34	0.28	0.24			0.07	0.11			0.28	0.28	0.28	0.28	0.34	0.34	0.34	
Share of Alternative Fuel Use in Dual-Fuel or PHEV (Energy %)																	95%
DEF Use (% of fuel consumption (GGE))	0%	0%	0%			0%	0%			0%	0%	0%	0%	0%	0%	0%	0%
Purchase Price (\$/unit)	\$12,000	\$16,000	\$0			\$23,000	\$0			\$0	\$0	\$0	\$0	\$0	\$13,500	\$0	\$0
Incentive (\$/unit)	\$0	\$0	\$0			\$0	\$0			\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Maintenance & Repair (\$/hr)	\$0.12	\$0.15	\$0.00			\$0.05	\$0.00			\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.12	\$0.00	\$0.00
<b>Large Equipment Inputs</b>																	
Off-Road Large Equipment Type	Forklifts																
Number of Large Equipment Units	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Hourly Usage	1,700	1,700				1,700	1,700	0	0	0	0	0	0	0	1,700	1,700	0
Rated Horsepower	50	50				50	50	50	50	50	50	50	50	50	50	50	50
Load Factor %	71%	59%				14%	24%	49%	49%	59%	59%	59%	59%	71%	71%	71%	59%
Fuel Consumption (GGE/hr)	0.80	0.67				0.16	0.27	0.56	0.56	0.67	0.67	0.67	0.67	0.80	0.80	0.80	0.7
Share of Alternative Fuel Use in Dual-Fuel or PHEV (Energy %)																	95%
DEF Use (% of fuel consumption (GGE))	0%	0%				0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Purchase Price (\$/unit)	\$22,000	\$30,000				\$37,000	\$40,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$25,000	\$50,000	\$0
Incentive (\$/unit)	\$0	\$0				\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Maintenance & Repair (\$/hr)	\$0.14	\$0.19				\$0.08	\$0.08	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.14	\$0.14	\$0.00

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<sub>x</sub> 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 10).

**Figure 10. 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
<b>Fuel Price Sensitivity</b>																
<b>Public Fuel Price Sensitivity Case</b>	<a href="#">No</a>															
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 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
<b>Private Fuel Price Sensitivity Case</b>	<a href="#">No</a>															
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 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 11). 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 as out of route mileage and fueling labor costs.

**Figure 11. 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
<b>Infrastructure Inputs</b>																
Station/EVSE Type	New Private	New Private	New Private	Level 1	Level 1	Level 2 - Home	New Private	New Private	New Private	New Private	New Private	New Private	New Private	New Private	New Private	New Private
Number of stations/EVSEs	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0
Total Refueling Station/EVSE Cost	\$0	\$0	\$0	\$720	\$720	\$1,200	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Total Incentive	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Maintenance Depot Cost	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Annual Private Station/EVSE Operation & Maintenance	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Default Refueling Station/EVSE Cost	\$0	\$0	\$0	\$720	\$720	\$1,200	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Default Annual Private Station/EVSE O&M Costs (L)	\$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
<b>Public Out of Route Mileage, Labor &amp; Misc. Costs</b>																
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
<b>Private Out of Route Mileage, Labor &amp; Misc. Costs</b>																
HD Annual Out of Route Mileage To Public Station	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HD Out of Route Vehicle Speed (miles/hr)	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
HD Labor Rate (\$/hr)	\$25	\$25	\$25	\$25	\$25	\$25	\$25	\$25	\$25	\$25	\$25	\$25	\$25	\$25	\$25	\$25
HD Annual Out of Route Labor Costs (\$/yr)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
HD Public Fueling Labor & Misc. Costs (\$/yr)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
LD Annual Public Station Out of Route/Fueling Lab	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
HD Annual Public Station Out of Route/Fueling Lab	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
LD Annual Private Station O&M Cost (\$/yr)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
HD Annual Private Station O&M Cost (\$/yr)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0

The other tables in this sheet include the calculation for simple payback, petroleum use, GHG emissions, air pollutant emissions, and externality costs. The calculation for simple payback is based on the acquisition and annual operating costs for a new AFV as compared to its conventional counterpart. Specifically, calculating the years (and miles) needed for the operating savings to payback the higher incremental acquisition cost. In cases where the operating costs for the AFV are higher than the costs of the conventional vehicle, there will be no payback calculated. 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 2020 for AFLEET Tool 2020). 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 the current AFLEET version, we used the most recent GREET model (Argonne 2020a). The 2018 version of GREET included 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<sub>2</sub>, VOC, NO<sub>x</sub>, PM<sub>2.5</sub>, PM<sub>10</sub>, and NH<sub>3</sub> emissions (Jaramillo and Muller 2016, Muller 2017). From this model, we use the VOC, NO<sub>x</sub>, PM<sub>2.5</sub>, and PM<sub>10</sub> 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 2019, 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-Onroad Output Sheet

This sheet summarizes the on-road output 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 12-14), 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 15-19). The following figures are shown as an example of the output generated; a user's results will vary depending on the specific inputs used.

**Figure 12. Payback Output 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
<b>Acquisition Cost</b>															
Light-Duty (LD) Fleet & Infrastructure	\$1,000,000		\$1,150,000		\$1,700,000	\$1,500,000	\$2,925,000				\$1,125,000		\$1,300,000	\$1,350,000	
Heavy-Duty (HD) Fleet & Infrastructure		\$10,500,000				\$33,500,000			\$12,500,000		\$10,500,000			\$13,000,000	
<b>Annual Operating Cost - Private Station Fueling</b>															
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	
<b>Incremental Acquisition Cost - Private Station Fueling</b>															
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	
<b>Annual Operating Savings - Private Station Fueling</b>															
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	
<b>Simple Payback (years) - Private Station Fueling</b>															
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	
<b>HD Refuse Truck Fleet</b>															
HD High Fuel Price Sensitivity						35.4			3.8		No payback			9.1	
HD Low Fuel Price Sensitivity						22.1			3.3		No payback			3.8	
						88.9			4.6		No payback			No payback	

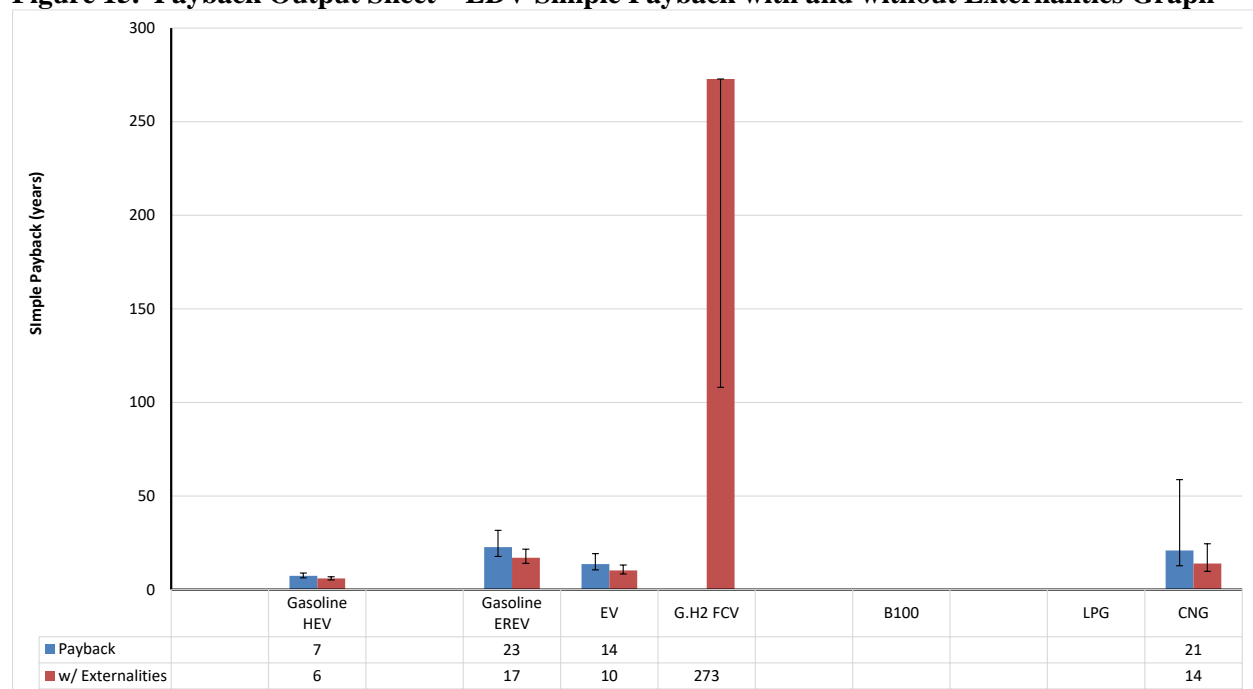
**Figure 13. Payback Output Sheet – Annual Energy Use and Emissions Summary Table**

	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
<b>Annual Life-Cycle Petroleum Use (barrels)</b>															
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	
<b>Annual Life-Cycle Greenhouse Gas Emissions (short tons)</b>															
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	
<b>Vehicle Operation Air Pollutant Emissions (lb)</b>															
<b>LD Passenger Car Fleet</b>															
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	
<b>HD Refuse Truck Fleet</b>															
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	

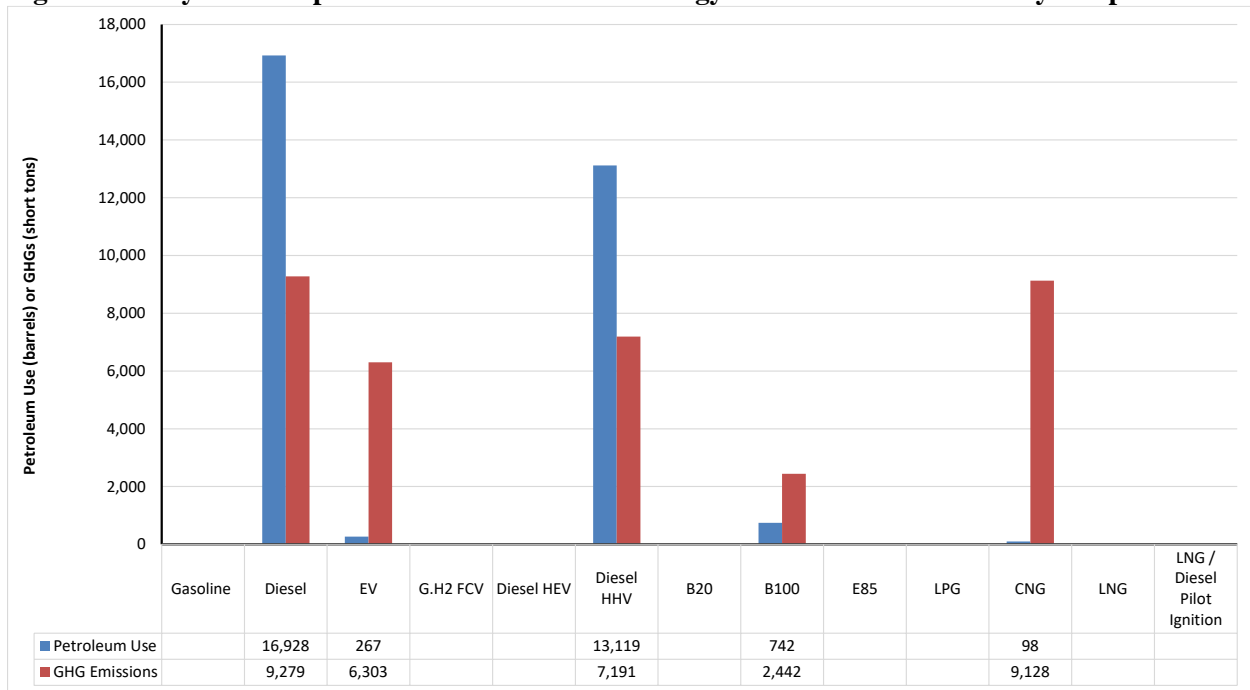
**Figure 14. Payback Output Sheet – Annual Externality Costs Summary Table**

	Gasoline	Diesel	HEV	PHEV	EREV	EV	G.H2 FCV	Diesel HEV	Diesel HHV	B20	B100	E85	LPG	CNG	LNG Pilot Ignition
<b>Life-Cycle Petroleum Use Costs</b>															
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	
<b>Life-Cycle GHG Emission Costs</b>															
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	
<b>Vehicle Operation Air Pollutant Emission Costs</b>															
<b>LD Passenger Car Fleet</b>															
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	
<b>HD Refuse Truck Fleet</b>															
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	
<b>Total Petroleum, GHG, and Air Pollutant Costs</b>															
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	
<b>Total Petroleum, GHG, and Air Pollutant Cost Savings</b>															
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	
<b>Annual Operating Savings with Externality Cost Savings</b>															
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	
<b>Simple Payback with Externality Costs (years)</b>															
<b>LD Passenger Car Fleet</b>															
LD High Fuel Price Sensitivity			6.0		17.0	10.3	272.7				No payback		No payback	14.0	
LD Low 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	
<b>HD Refuse Truck Fleet</b>															
HD High Fuel Price Sensitivity						22.4			3.0		No payback			4.6	
HD Low Fuel Price Sensitivity						16.3			2.7		No payback			2.7	
HD Low Fuel Price Sensitivity						36.2			3.5		No payback			16.8	

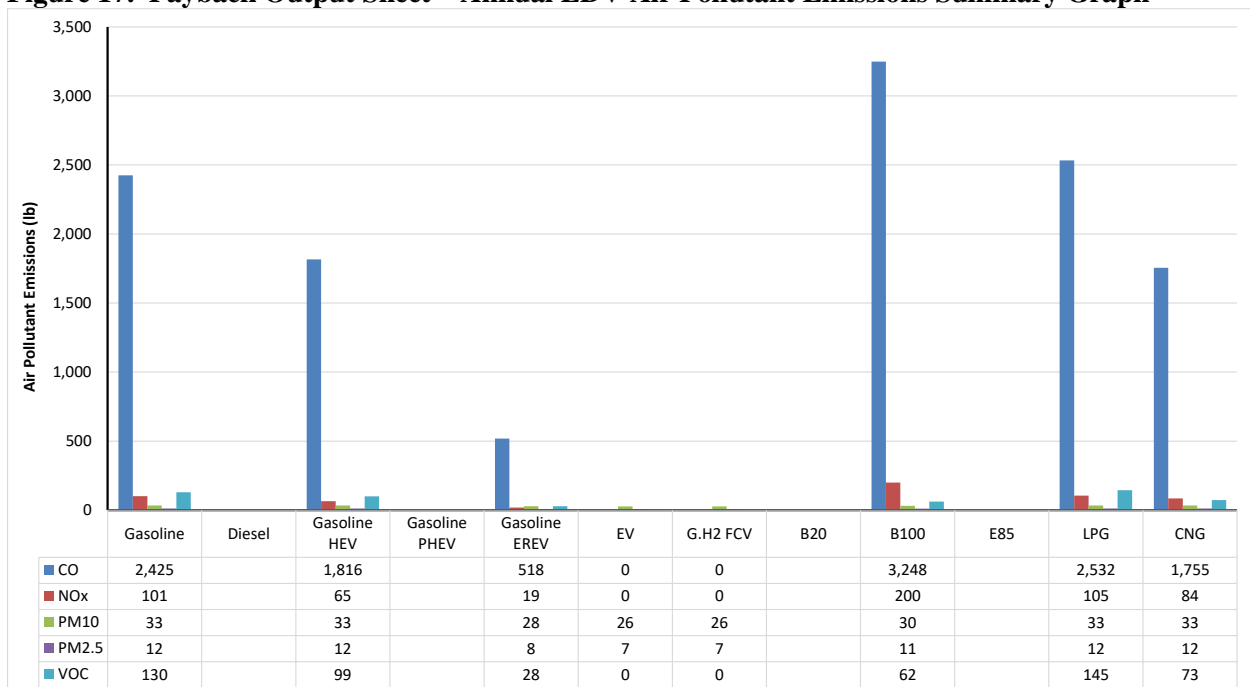
**Figure 15. Payback Output Sheet – LDV Simple Payback with and without Externalities Graph**



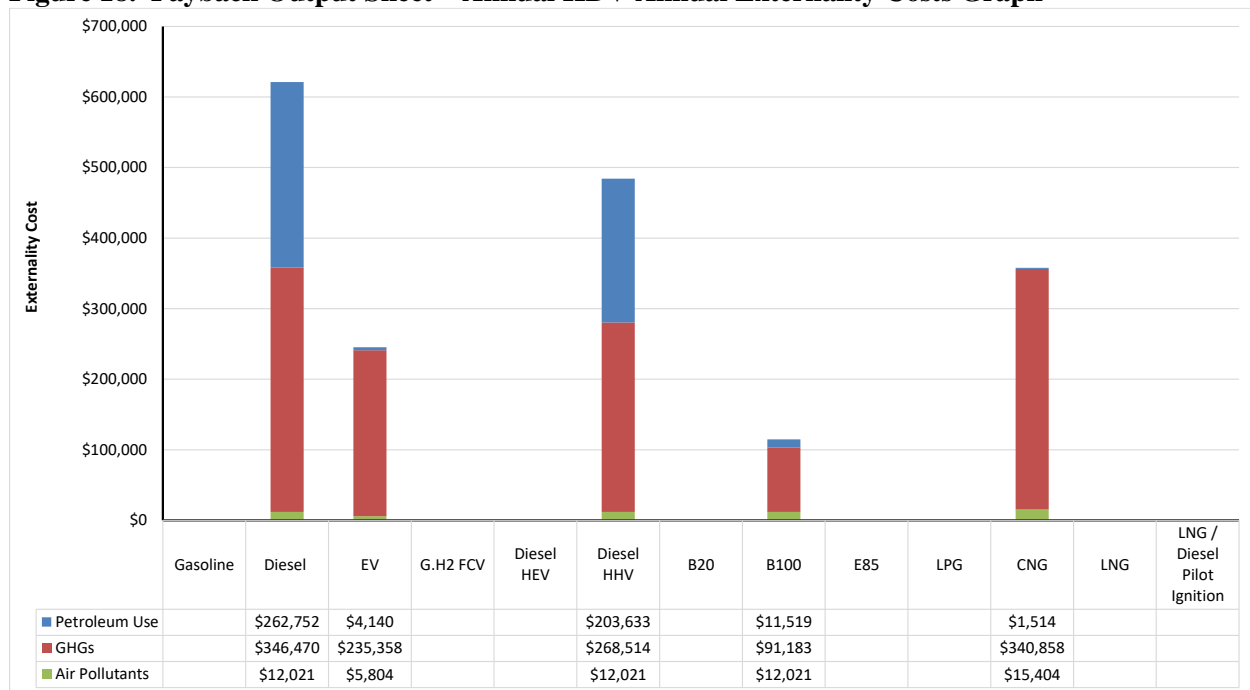
**Figure 16. Payback Output Sheet – Annual HDV Energy Use and GHGs Summary Graph**



**Figure 17. Payback Output Sheet – Annual LDV Air Pollutant Emissions Summary Graph**



**Figure 18. Payback Output Sheet – Annual HDV Annual Externality Costs Graph**



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



## 2.5 Payback-Offroad Output Sheet

This sheet summarizes the off-road output 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, both small equipment and large equipment are included, while small equipment and large equipment simple payback, energy use and emissions, and externality costs are presented separately in the graphs. The tables and graphs for off-road equipment are exactly the same as for the Payback-Onroad Output sheet (Figures 12-19).

## **2.6 TCO Sheet**

This sheet contains the Total Cost of Ownership Calculator, which evaluates the net present value of operating and fixed costs of 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 blue hyperlink for “Annual Mileage” (Figure 20), 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 21). 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 20. TCO Sheet – LDV Characteristics and Cost Calculations**

**Total Cost of Ownership Calculator**

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

**Figure 21. TCO Sheet – LDV Energy Use and Emissions and externality Costs Calculations**

Total Cost of Ownership Calculator		Project Year				
Annual Gasoline Passenger Car Fleet Petroleum Use, GHGs, and Air Pollutants		1	2	3	4	5
<b>Well-to-Wheels Petroleum and GHGs</b>						
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
<b>Vehicle Production Petroleum and GHGs</b>						
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
<b>Vehicle Operation Air Pollutants</b>						
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
<b>Upstream Air Pollutants</b>						
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
<b>Vehicle Production Air Pollutants</b>						
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
<b>Annual Gasoline Passenger Car Fleet Petroleum Use, GHG, and Air Pollutant Externality Costs</b>						
<b>Well-to-Wheels Petroleum and GHG Externality Costs</b>						
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
<b>Vehicle Production Petroleum and GHG Externality Costs</b>						
LD Petroleum Use	\$/year	\$0	\$0	\$0	\$0	\$0
LD GHGs	\$/year	\$0	\$0	\$0	\$0	\$0
<b>Vehicle Emissions Air Pollutant Externality Costs</b>						
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
<b>Upstream Air Pollutant Externality Costs</b>						
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
<b>Vehicle Production Air Pollutant Externality Costs</b>						
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
<b>Total Petroleum Use, GHGs, and Air Pollutants &amp; Externality Costs - Per Lifetime Ownership of Gasoline Passenger Car Fleet</b>						
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

## 2.7 TCO Output Sheet

This sheet summarizes the output 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 22-24), both LDVs and HDVs are included, while LDVs and HDVs are presented separately in the graphs (Figures 25-32). This sheet has additional cost graphs as compared to the Payback Output sheet. Specically, the cumulative cost of ownership compared to a conventional counterpart (Figure 25) 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 26 shows the cumulative cash flow for both AFVs and conventional vehicles. Figure 27 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 28 show the total cost of ownership but also include externalitiy costs. The following figures are shown as an example of the output generated; a user's results will vary depending on the specific inputs used.

**Figure 22. TCO Output 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
<b>Light-Duty Passenger Car Fleet and Infrastructure</b>																
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		
<b>Heavy-Duty Refuse Truck Fleet and Infrastructure</b>																
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		

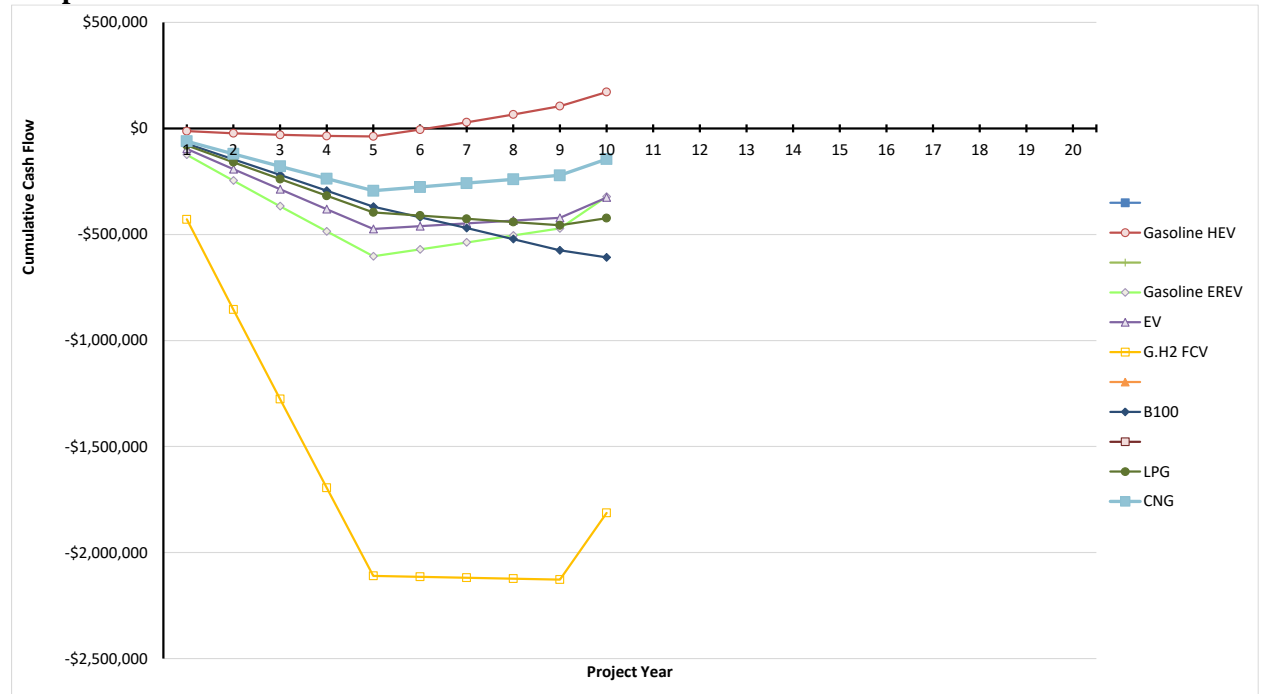
**Figure 23. TCO Output Sheet – Lifetime Energy Use and Emissions Summary Table**

	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
<b>Lifetime Life-Cycle Petroleum Use (barrels)</b>																
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		
<b>Lifetime Life-Cycle Greenhouse Gas Emissions (short tons)</b>																
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		
<b>Lifetime Vehicle Operation Air Pollutant Emissions (lb)</b>																
<b>Light-Duty Passenger Car Fleet</b>																
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		
<b>Heavy-Duty Refuse Truck Fleet</b>																
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		

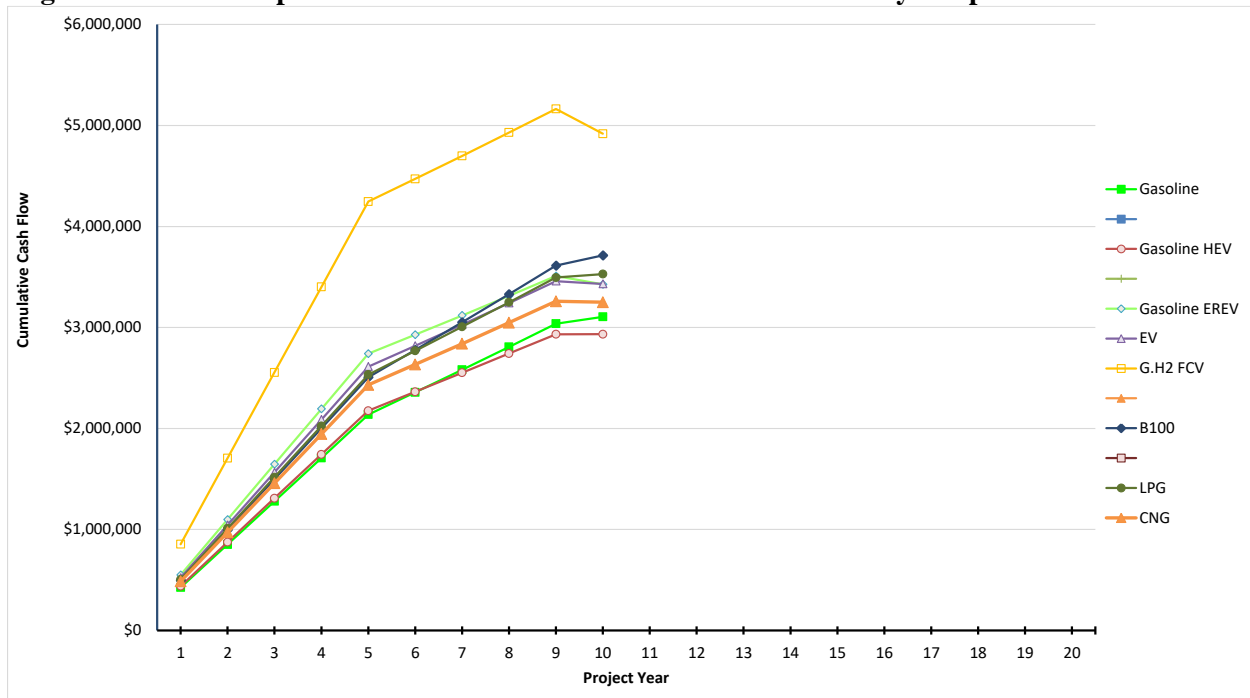
**Figure 24. TCO Output Sheet – Lifetime externality Costs Summary Table**

	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
<b>Lifetime Life-Cycle Petroleum Use Costs</b>																
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		
<b>Lifetime Life-Cycle Greenhouse Gas Emission Costs</b>																
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		
<b>Lifetime Vehicle Operation Air Pollutant Emission Costs</b>																
<b>Light-Duty Passenger Car Fleet</b>																
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		
<b>Heavy-Duty Refuse Truck Fleet</b>																
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				\$94,100			\$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		
<b>Lifetime Total Petroleum, GHG, and Air Pollutant Costs</b>																
LD Fleet			\$148,289		\$85,608	\$107,874	\$77,364				\$40,522		\$139,833	\$109,920		
HD Fleet		\$6,933,492			\$85,608	\$2,741,081			\$5,404,818		\$1,284,731			\$3,994,915		
<b>Light-Duty Passenger Car Fleet and Infrastructure TCO with Externalities</b>																
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		
<b>Heavy-Duty Refuse Truck Fleet and Infrastructure TCO with Externalities</b>																
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		

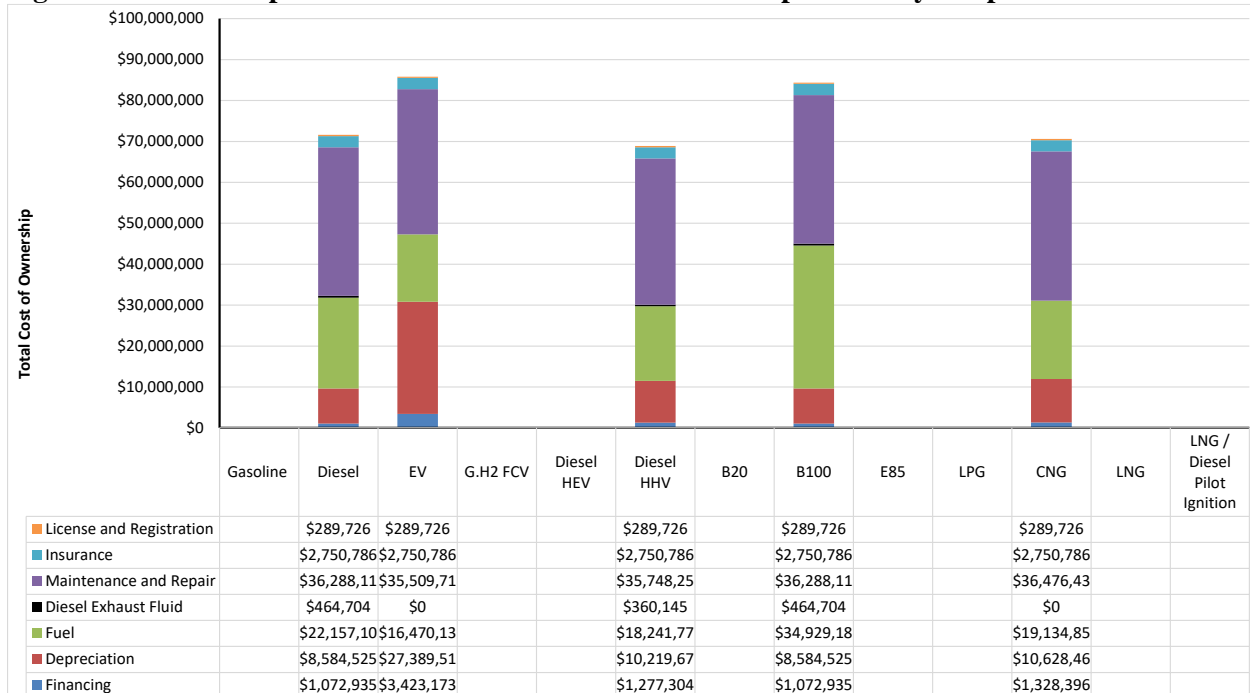
**Figure 25. TCO Output Sheet – LDV Cumulative Cash Flow Compared to Gasoline Summary Graph**



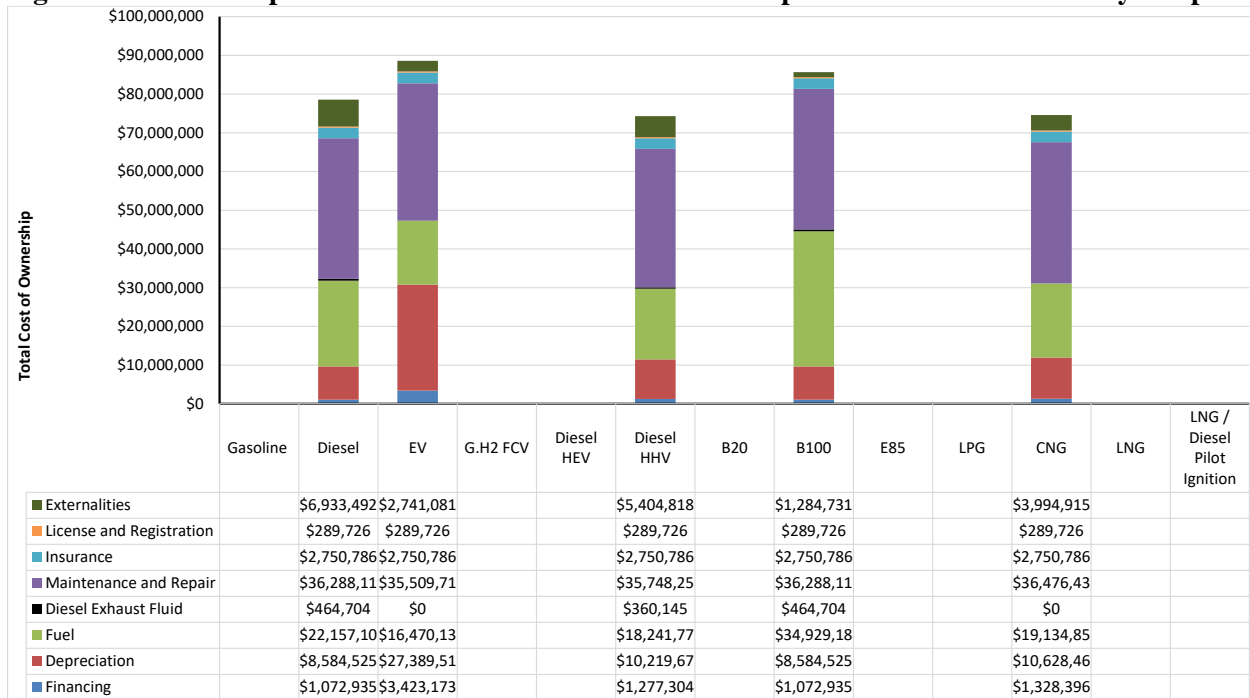
**Figure 26. TCO Output Sheet – LDV Cumulative Cash Flow Summary Graph**



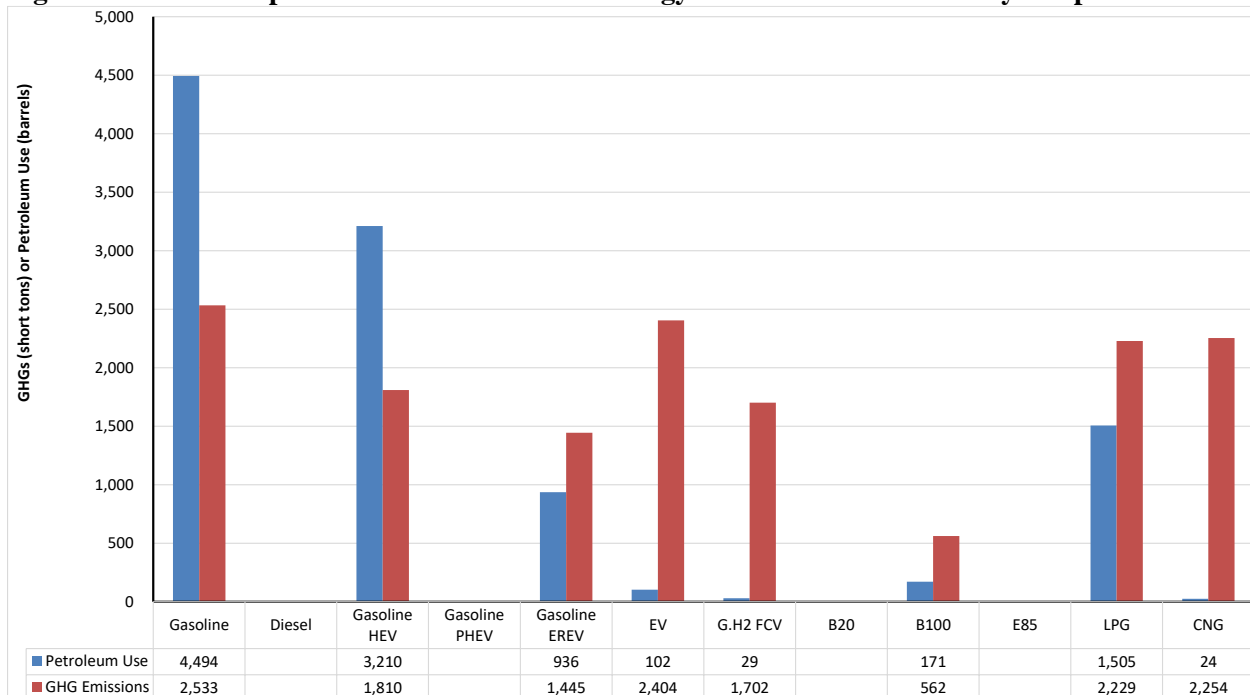
**Figure 27. TCO Output Sheet – HDV Total Cost of Ownership Summary Graph**



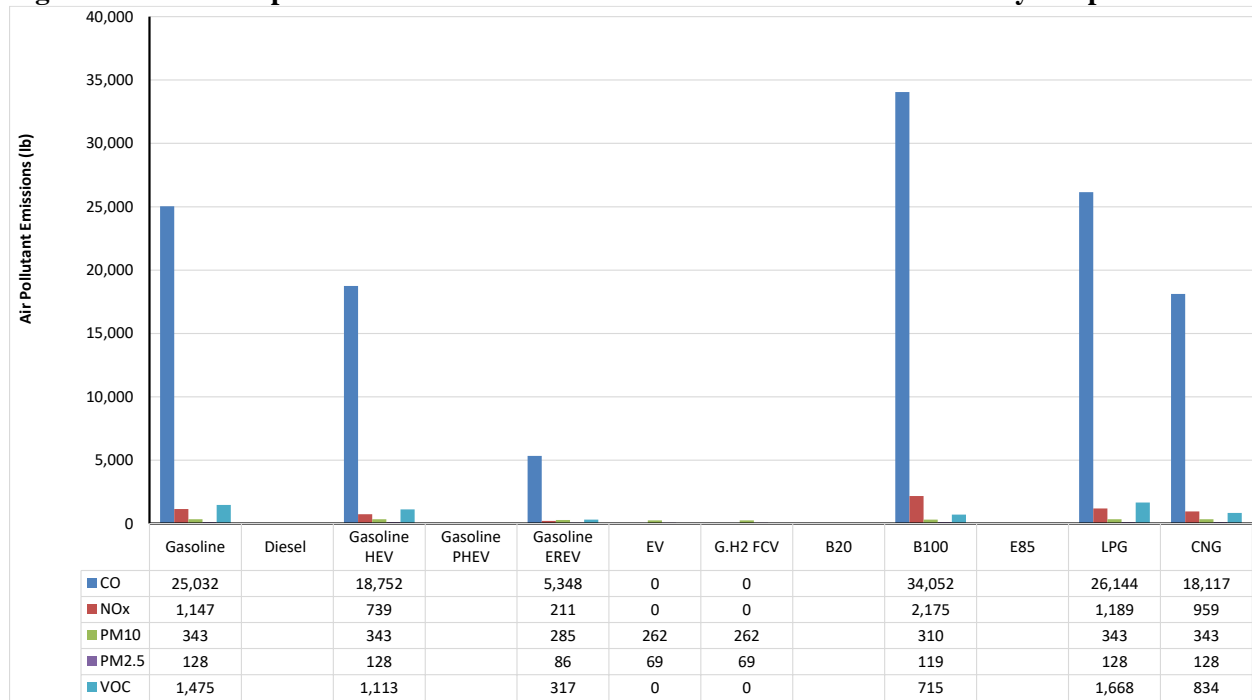
**Figure 28. TCO Output Sheet – HDV Total Cost of Ownership w/ Externalities Summary Graph**



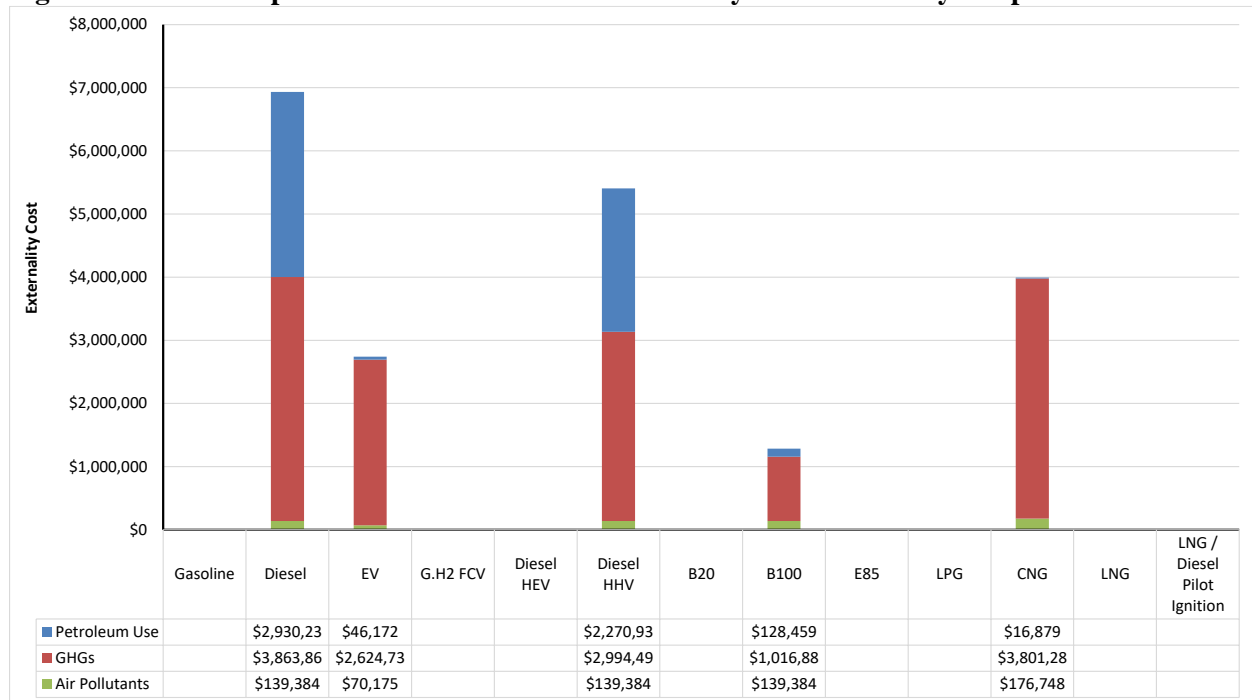
**Figure 29. TCO Output Sheet – Lifetime LDV Energy Use and GHGs Summary Graph**



**Figure 30. TCO Output Sheet – Lifetime LDV Air Pollutant Emissions Summary Graph**



**Figure 31. TCO Output Sheet – Lifetime HDV Externality Costs Summary Graph**



**Figure 32. TCO Output Sheet – Lifetime LDV Detailed Externality Costs Summary Graph**



## 2.8 Footprint-Onroad Sheet

This sheet contains the On-Road Fleet Footprint Calculator, which estimates the current year and remaining lifetime petroleum use, GHGs, air pollutant emissions, and externality costs of existing and new on-road vehicles, taking into consideration that older vehicles typically have higher air pollutant emission rates than newer ones. The key inputs (Figure 33) 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 1990 and 2025, vehicle mileage, and fuel use to estimate its energy use, emissions, and externality costs (Figure 34) of existing fleet vehicles and vehicles planned to be purchased. If you want to estimate the remaining lifetime, the user can either 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 2020) below the existing rows.



**Figure 33. Footprint-Onroad Sheet - Inputs**

State																			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 34. Footprint-Onroad 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	\$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	\$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	\$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	\$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	\$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	\$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	\$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	\$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	\$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	\$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	\$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	\$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	\$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	\$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	\$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	\$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	\$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	\$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	\$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	\$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	\$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	\$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	\$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	\$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	\$0	\$0

## 2.9 Footprint-Offroad Sheet

This sheet contains the Off-Road Fleet Footprint Calculator, which estimates the current year and remaining lifetime petroleum use, GHGs, air pollutant emissions, and externality costs of existing and new off-road equipment, taking into consideration that older equipment typically have higher air pollutant emission rates than newer ones.

As mentioned previously, the 21 equipment types in AFLEET 2020 are based on the EPA MOVES3 (NONROAD) and fall under six equipment categories:

**Agricultural**

- **agricultural tractors**

**Airport Support**

- **airport support equipment**

**Construction**

- **cranes**
- **crawler tractor/dozers**
- **excavators**
- **rollers**
- **rubber tire loaders**
- **skid steer loaders**
- **tractors/loaders/backhoes**

**Industrial**

- **aerial lifts**
- **forklifts**
- **sweepers/scrubbers**
- **terminal tractors**

**Lawn & Garden**

- **chain saws**
- **commercial turf equipment**
- **lawn & garden tractors**
- **lawn mowers**
- **leafblowers/vacuums**
- **snowblowers**
- **trimmers/edgers/brush cutter**

**Recreational**

- **golf carts**

The key inputs (Figure 35) for this sheet are:

- **equipment type**
- **model year**
- **annual hourly usage**
- **rated horsepower**
- **fuel use**
- **remaining lifetime.**

The user can change the equipment types via dropdown box. The user then must enter a model year between 1971 and 2025, equipment annual hourly usage, rated horsepower, and fuel use to estimate its energy use, emissions, and externality costs (Figure 36) of existing fleet equipment and equipment planned to be purchased. Default data is provided for these key inputs

are provided for reference to the right of the fuel use columns, but the user must enter these or other values, as they are not used automatically.

If you want to estimate the remaining lifetime, the user can either can enter the remaining lifetime in this sheet. If the user would like to examine more equipment than is provided in this sheet, the user can copy and paste the entire row(s) with calculations (rows 6-65 in AFLEET Tool 2019) below the existing rows.

**Figure 35. Footprint-Offroad Sheet - Inputs**

State																Year										2019
ILLINOIS																										
Equipment Type	Model Year	Annual Usage (hours)	Rated Horsepower (hp)	Fuel Use														Remaining Lifetime						Remaining Years		
				Gasoline (gal)	Diesel (gal)	Electricity (kWh)	G.H2 (kg)	R20 (gal)	B100 (gal)	R20 (gal)	R100 (gal)	E85 (gal)	LPG (gal)	CNG (GGE)	LNG (gal)	Default Annual Usage (hr)	Default Rated Horsepower (hp)	Default Estimated Gasoline Use (gal)	Default Estimated Electricity Use (kWh)	Median Life Full Load (hr)	Calculated Lifetime (hr)	Cumulative Hours				
Aerial Lifts																361	41	154	1,269	3,000	0	0	0	0		
Aerial Lifts																361	41	154	1,269	3,000	0	0	0	0		
Agricultural Tractors																55	65	50	413	3,000	0	0	0	0		
Agricultural Tractors																55	65	50	413	3,000	0	0	0	0		
Airport Support Equipment																681	43	372	3,057	3,000	0	0	0	0		
Airport Support Equipment																681	43	372	3,057	3,000	0	0	0	0		
All Terrain Vehicles																3,216	2	146	1,199	3,000	0	0	0	0		
All Terrain Vehicles																3,216	2	146	1,199	3,000	0	0	0	0		
Chain Saws																33	3	2	13	400	0	0	0	0		
Chain Saws																33	3	2	13	400	0	0	0	0		
Commercial Turf Equipment																1,364	25	464	3,814	3,000	0	0	0	0		
Commercial Turf Equipment																1,364	25	464	3,814	3,000	0	0	0	0		
Cranes																415	44	195	1,600	3,000	0	0	0	0		
Cranes																415	44	195	1,600	3,000	0	0	0	0		
Crawler Tractor/Dozers																936	568	7,114	58,476	3,000	0	0	0	0		
Crawler Tractor/Dozers																936	568	7,114	58,476	3,000	0	0	0	0		
Excavators																192	499	1,282	10,538	3,000	0	0	0	0		
Excavators																192	499	1,282	10,538	3,000	0	0	0	0		
Forklifts																18	99	12	100	3,000	0	0	0	0		
Forklifts																18	99	12	100	3,000	0	0	0	0		
Golf Carts																18	9	2	14	400	0	0	0	0		
Golf Carts																18	9	2	14	400	0	0	0	0		

**Figure 36. Footprint-Offroad Sheet - Energy Use, Emissions, and Externality Cost Calculations**

Equipment Type	Well-to-Wheels Petroleum Use (barrels)	Well-to-Wheels GHGs (short tons)	Equipment Operation Air Pollutants (lb)								Upstream Air Pollutants (lb)						Externality Cost	
			CO	NOx	PM10	PM2.5	VOC	VOC (Evap)	SOx	CO	NOx	PM10	PM2.5	VOC	VOC (Evap)	SOx	Well-to-Wheels Petroleum Use	Well-to-Wheels GHGs
Aerial Lifts	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0
Aerial Lifts	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0
Agricultural Tractors	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0
Agricultural Tractors	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0
Airport Support Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0
Airport Support Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0
All Terrain Vehicles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0
All Terrain Vehicles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0
Chain Saws	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0
Chain Saws	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0
Commercial Turf Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0
Commercial Turf Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0
Cranes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0
Cranes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0
Crawler Tractor/Dozers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0
Crawler Tractor/Dozers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0
Excavators	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0
Excavators	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0
Forklifts	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0
Forklifts	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0
Golf Carts	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0
Golf Carts	0.0	0.0	0.0	0.0	0.0	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 Output Sheet

This sheet summarizes the output of both the On-Road Fleet Footprint Calculator and the Off-Road 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 37-41). The following figures are shown as an example of the output generated; a user's results will vary depending on the specific inputs used.

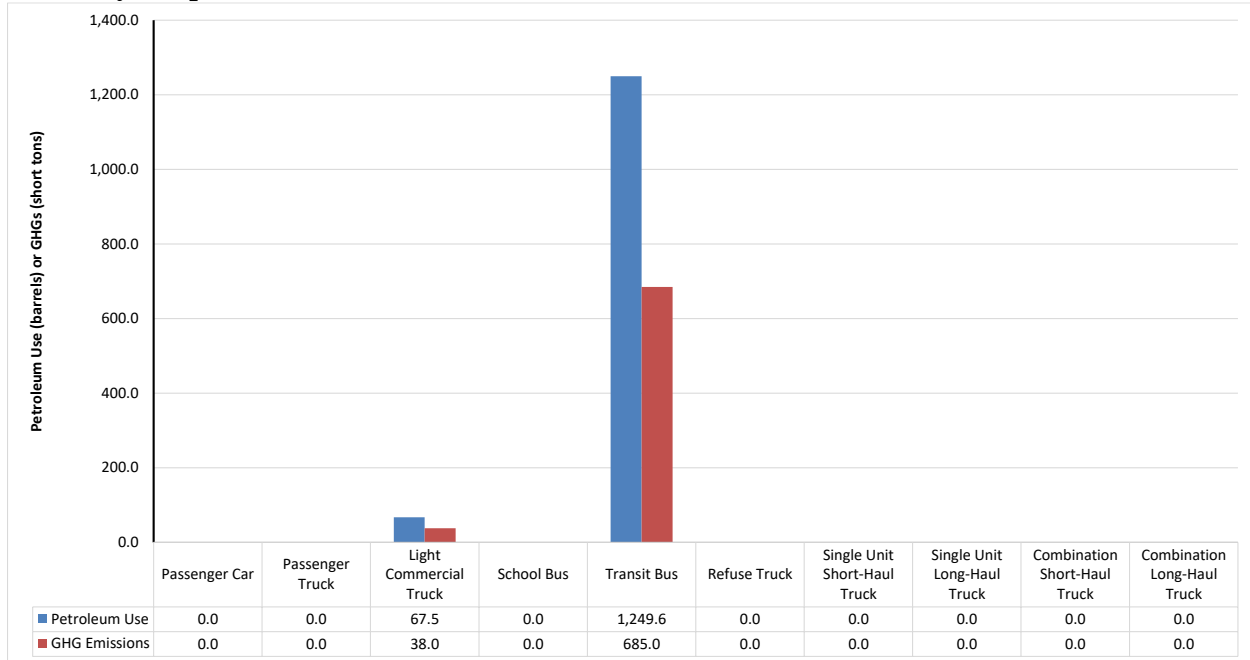
**Figure 37. Footprint Output Sheet – Current Year On-Road Fleet Energy Use and Emissions Summary Table**

Current Year On-Road - Well-to-Wheels & Vehicle Production* Petroleum Use, GHGs, Air Pollutants (*LDVs only) by Vehicle Type								
Vehicle Type	Petroleum Use (barrels)	GHGs (short tons)	CO (lb)	NOx (lb)	PM10 (lb)	PM2.5 (lb)	VOC (lb)	SOx (lb)
Passenger Car	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
Light Commercial Truck	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
Transit Bus	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
Single Unit Short-Haul Truck	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
Combination Short-Haul Truck	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
Total	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

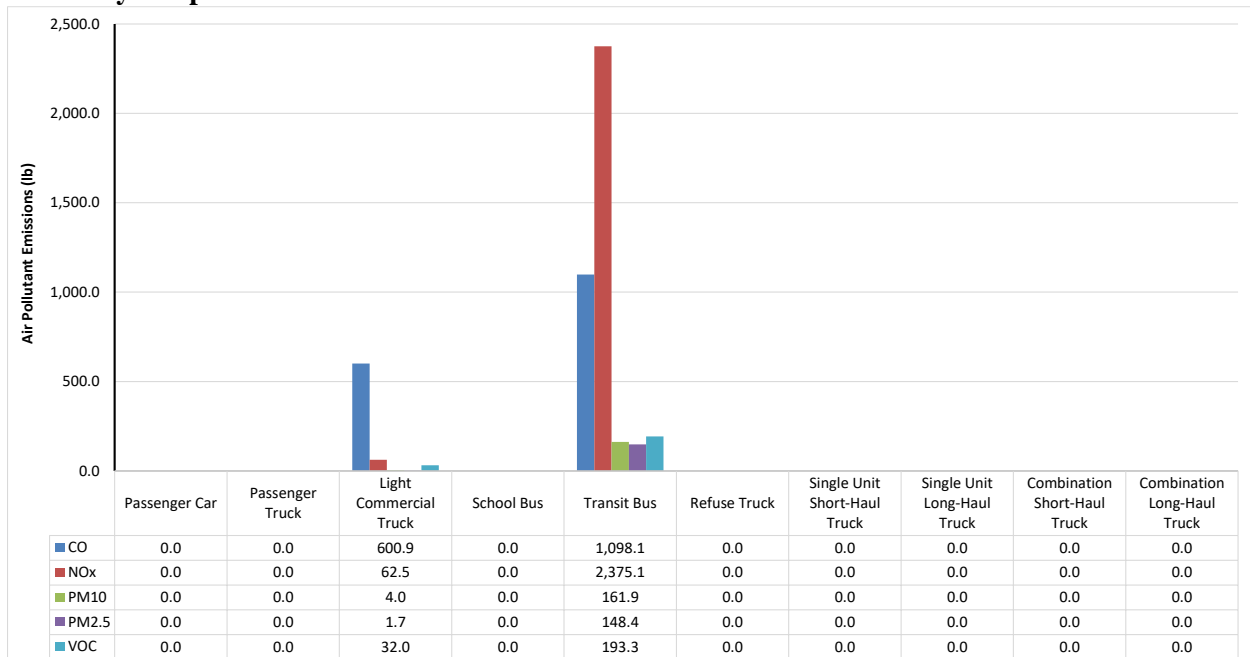
**Figure 38. Footprint Output Sheet – Remaining Lifetime Off-Road Fleet Externality Costs Summary Table**

Remaining Lifetime Off-Road - Energy Use and Emission Externality Costs by Vehicle Type								
Vehicle Type	Petroleum Use (\$)	GHGs (\$)	CO (\$)	NOx (\$)	PM10 (\$)	PM2.5 (\$)	VOC (\$)	SOx (\$)
Aerial Lifts	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Agricultural Tractors	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Airport Support Equipment	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
All Terrain Vehicles	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Chain Saws	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Commercial Turf Equipment	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Cranes	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Crawler Tractor/Dozers	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Excavators	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Forklifts	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Golf Carts	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Lawn & Garden Tractors	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Lawn Mowers	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Leafblowers/Vacuums	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Rollers	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Rubber Tire Loaders	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Skid Steer Loaders	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Snowblowers	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Sweepers/Scrubbers	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Terminal Tractors	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Tractors/Loaders/Backhoes	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Trimmers/Edgers/Brush Cutter	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Total	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0

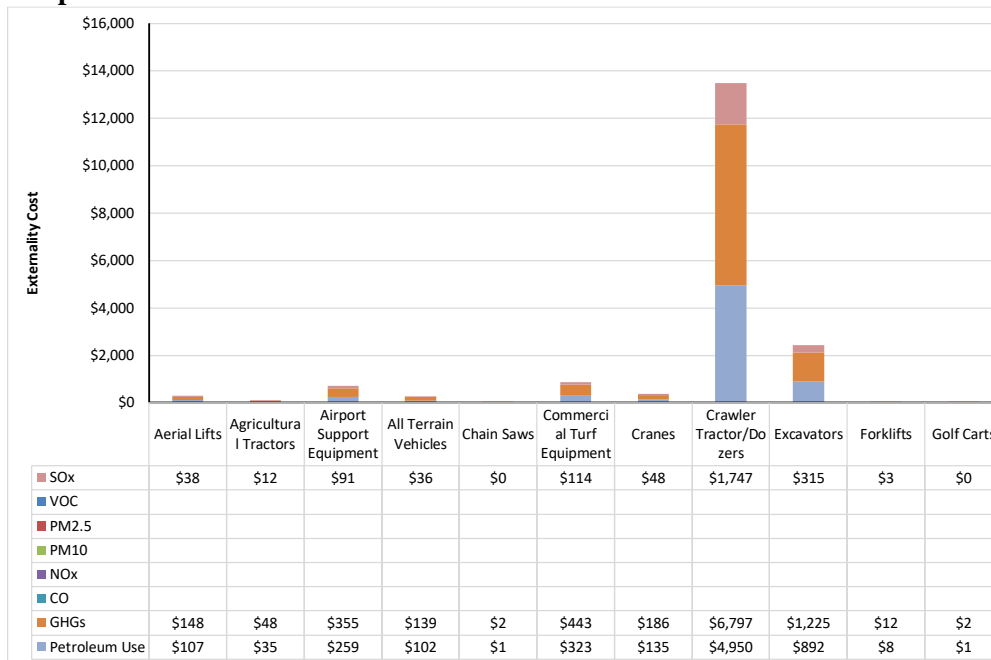
**Figure 39. Footprint Output Sheet – Current Year On-Road Fleet Energy Use and GHGs Summary Graph**



**Figure 40. Footprint Output Sheet – Remaining Lifetime On-Road Fleet Air Pollutant Emissions Summary Graph**



**Figure 41. Footprint Output Sheet – Current Year Off-Road Fleet Externality Costs Summary Graph**



## 2.11 Charging Sheet

This sheet contains the Electric Vehicle Charging Calculator, which estimates the annual petroleum use, GHGs, and air pollutant benefits of utilizing public electric vehicle charging infrastructure. Key assumptions for level 2 and DC fast charging utilization, average session power, and charge time from the Inputs sheet are fed into the Charging sheet; lev and DC Fast charger inputs are shown as an example (Figure 42). The other tables in this sheet include the petroleum use, GHG emissions, air pollutant emissions, and externality costs.

**Figure 42. Charging Sheet – Level 2 and DC Fast EV Charging Inputs**

	Parking Lot	Retail & Leisure	Education	Healthcare	Workplace	Multi-Unit Dwelling	Single-Unit Dwelling
Charging Location Category	Public	Public	Public	Public	Workplace	Residential	Residential
<b>Level 2 Charger Inputs</b>							
Default Weekly Level 2 (L2) Utilization	Moderate						
Number of L2 Chargers	1	2	3	4	5	6	7
Weekly Utilization (sessions/week)	4.5	5.5	6.0	6.5	4.5	3.0	6.0
Daily Utilization (sessions/day)	0.6	0.8	0.9	0.9	0.6	0.4	0.9
Average Session Power (kW)	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Average Charge Time (hours/session)	2.5	1.5	2.5	2.5	2.5	3.5	2.0
Electricity Dispensed (kWh/session)	10.0	6.0	10.0	10.0	10.0	14.0	8.0
Electricity Dispensed (kWh/day)	6.4	9.4	25.7	37.1	32.1	36.0	48.0
Electricity Dispensed (kWh/year)	2,346	3,441	9,386	13,557	11,732	13,140	17,520
Annual EV Miles from L2 Charging	6,661	9,770	26,645	38,487	33,306	37,303	49,737
<b>DC Fast Charger Inputs</b>							
Default Weekly DC Fast Utilization	Moderate						
Number of DC Fast Chargers	1	1	1	1	1	1	1
Weekly Utilization (sessions/week)	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Daily Utilization (sessions/day)	2.1	2.1	2.1	2.1	2.1	2.1	2.1
Average Session Power (kW)	24.0	24.0	24.0	24.0	24.0	24.0	24.0
Average Charge Time (hours/session)	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Electricity Dispensed (kWh/session)	8.6	8.6	8.6	8.6	8.6	8.6	8.6
Electricity Dispensed (kWh/day)	18.5	18.5	18.5	18.5	18.5	18.5	18.5
Electricity Dispensed (kWh/year)	6,758	6,758	6,758	6,758	6,758	6,758	6,758
Annual EV Miles from DC Fast Charging	19,184	19,184	19,184	19,184	19,184	19,184	19,184

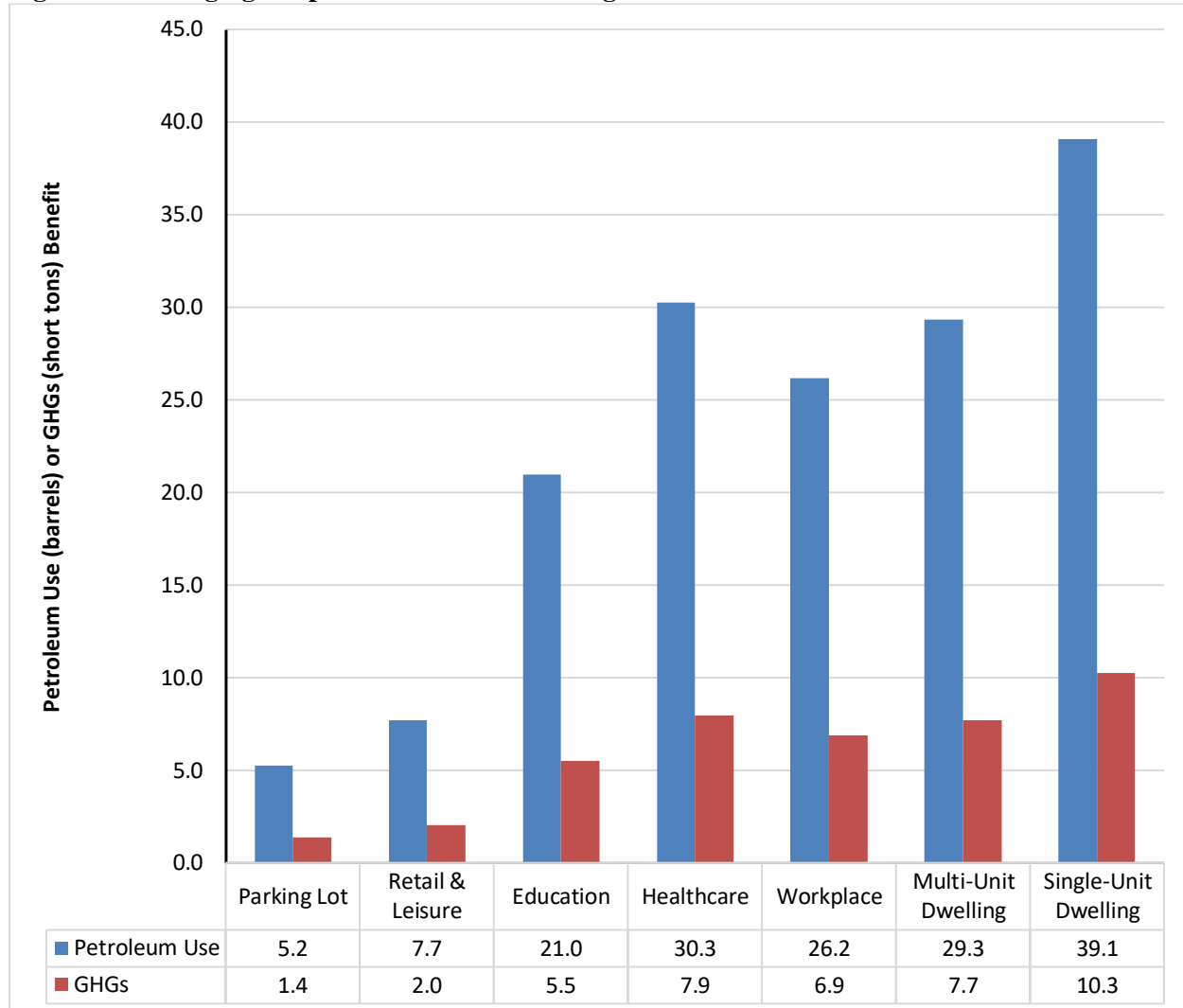
## 2.12 Charging Output Sheet

This sheet summarizes the output of the Electric Vehicle Charging Calculator with tables and graphs for petroleum use, GHG, and air pollutant benefits, as well as electricity dispensed. In the energy use and emissions, and externality cost tables, both level 2 and DC fast chargers are included, while energy use and emissions, and externality costs are presented separately in the graphs. The following figures are shown as an example of the output generated; a user's results will vary depending on the specific inputs used.

**Figure 43. Charging Output Sheet – Annual Energy Use and Emissions Summary Table**

Venue	Petroleum Use (barrels)	GHGs (short tons)	CO (lb)	NOx (lb)	PM10 (lb)	PM2.5 (lb)	VOC (lb)	SOx (lb)	Electricity Dispensed (kWh)
<b>Level 2 Chargers</b>									
Parking Lot	5.2	1.4	22.4	1.1	-0.4	0.0	4.1	-10.2	2,346
Retail & Leisure	7.7	2.0	32.8	1.6	-0.5	-0.1	6.1	-14.9	3,441
Education	21.0	5.5	89.4	4.4	-1.5	-0.2	16.6	-40.7	9,386
Healthcare	30.3	7.9	129.2	6.4	-2.1	-0.2	23.9	-58.8	13,557
Workplace	26.2	6.9	111.8	5.5	-1.8	-0.2	20.7	-50.9	11,732
Multi-Unit Dwelling	29.3	7.7	125.2	6.2	-2.1	-0.2	23.2	-57.0	13,140
Single-Unit Dwelling	39.1	10.3	166.9	8.3	-2.8	-0.3	30.9	-76.0	17,520
L2 Charger Total	158.8	41.7	677.6	33.5	-11.2	-1.2	125.5	-308.4	71,123
<b>DC Fast Chargers</b>									
Parking Lot	15.1	4.0	64.4	3.2	-1.1	-0.1	11.9	-29.3	6,758
Retail & Leisure	15.1	4.0	64.4	3.2	-1.1	-0.1	11.9	-29.3	6,758
Education	15.1	4.0	64.4	3.2	-1.1	-0.1	11.9	-29.3	6,758
Healthcare	15.1	4.0	64.4	3.2	-1.1	-0.1	11.9	-29.3	6,758
Workplace	15.1	4.0	64.4	3.2	-1.1	-0.1	11.9	-29.3	6,758
Multi-Unit Dwelling	15.1	4.0	64.4	3.2	-1.1	-0.1	11.9	-29.3	6,758
Single-Unit Dwelling	15.1	4.0	64.4	3.2	-1.1	-0.1	11.9	-29.3	6,758
DC Fast Charger Total	105.6	27.7	450.6	22.3	-7.4	-0.8	83.5	-205.1	47,304

**Figure 44. Charging Output Sheet – Level 2 Charger Petroleum Use and GHGs Benefit**



## 2.13 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 45). 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 45. 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
<b>Light-Duty Vehicle Inputs</b>											
IR Vehicle Type	<a href="#">Passenger Car</a>										
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)											
<b>Electrical Power Demand (W)</b>											
Charges/Day			0	0	250		250	250	250		
Days Driven/Week					1		1	1	1		
Weeks Driven/Year					5		5	5	5		
Battery Runtime (hr)					52		52	52	52		
Potential Battery/IR Use (hr/yr)					1.9		1.9	1.9	1.9		
Battery Share of Annual Idling Hours					505		505	505	505		
Charging Type					85%		43%	43%	43%		
% of Time Batteries Charged By Shore Power					Engine		Engine	Engine	Engine		
% of Time Batteries Charged By Engine					0%		0%	0%	0%		
Share of Annual Idling Hours Reduction Goal (%)			100%	100%	85%		43%	62%	100%		
<b>IR Equipment Service Hours:</b>											
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		
<b>Total LD Maintenance Cost (\$/yr)</b>	<b>\$470</b>		<b>\$355</b>	<b>#DIV/0!</b>	<b>\$459</b>		<b>\$459</b>	<b>\$344</b>	<b>\$280</b>		

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.

## 2.14 IR Output Sheet

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

**Figure 46. IR Output 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)	(Battery) & APU (Battery)	(Battery) & Fuel Operated Air	(Battery) & Battery Managemen	Truck Stop Electrification - Single System	Shore Power
<b>Acquisition Cost</b>											
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
<b>Annual Idling Operating Cost - Private Station Fueling</b>											
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
<b>Annual Idling Operating Savings - Private Station Fueling</b>											
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
<b>Simple Payback (years)</b>											
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

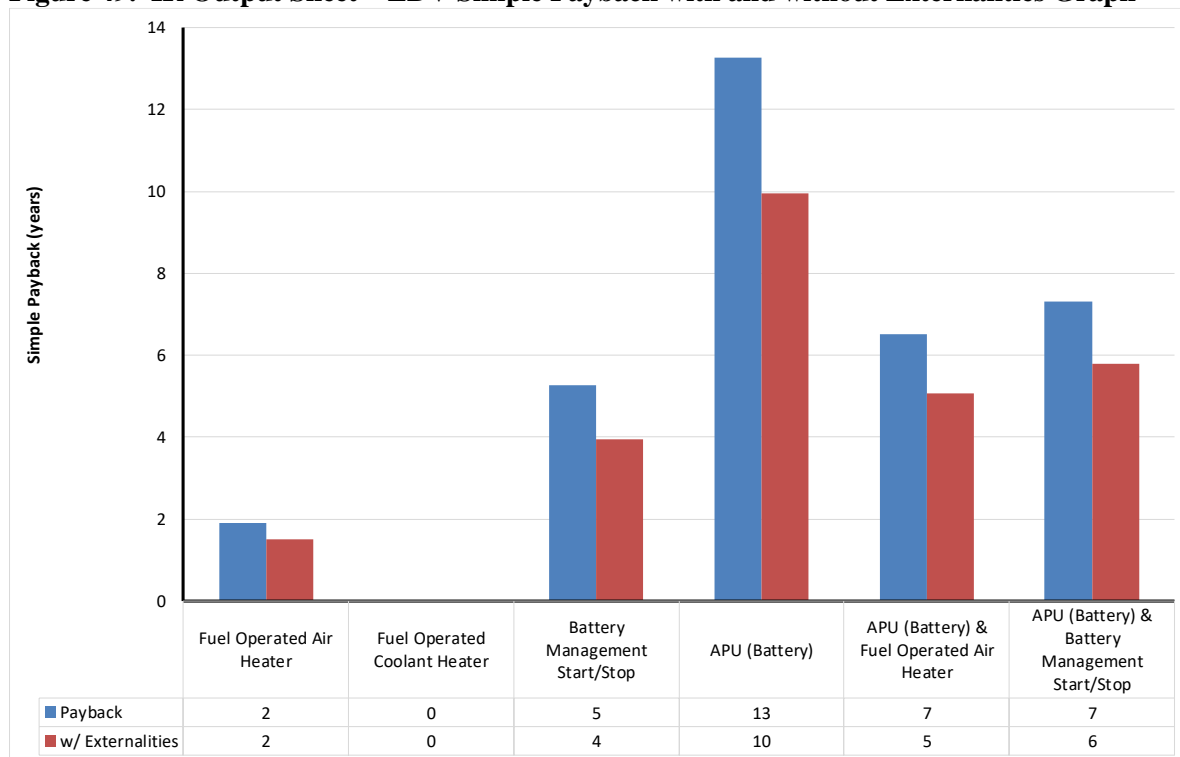
**Figure 47. IR Output Sheet – Annual Energy Use and Emissions Summary Table**

	Gasoline LDV (Baseline)	Diesel HDV (Baseline)	Fuel Operated Air Heater	Operated Coolant Heater	Battery Managemen t Start/Stop	APU (Diesel)	(Battery) & APU (Battery)	(Battery) & Fuel Operated Air	(Battery) & Battery Managemen	Truck Stop Electrification - Single System	Shore Power
<b>Annual Well-to-Wheels Idling Petroleum Use (barrels)</b>											
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
<b>Annual Well-to-Wheels Idling GHGs (short tons)</b>											
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
<b>Annual Vehicle Operation Idling Air Pollutants (lb)</b>											
<b>LD Passenger Car Fleet</b>											
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		
<b>HD Combination Long-Haul Truck Fleet</b>											
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

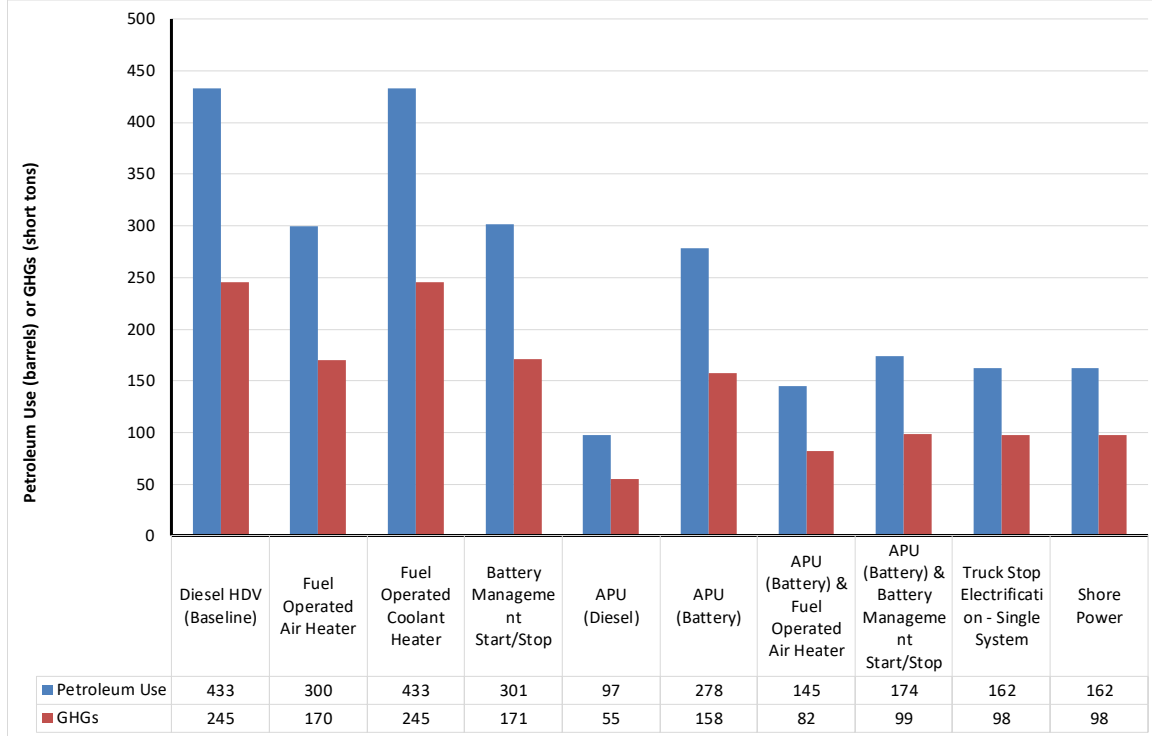
**Figure 48. IR Output Sheet – Annual Externality Costs Summary Table**

	Gasoline LDV (Baseline)	Diesel HDV (Baseline)	Fuel Operated Air Heater	Operated Coolant Heater	Battery Managemen t Start/Stop	APU (Diesel)	(Battery) & APU (Battery)	(Battery) & Fuel Operated Air Managemen	Battery Electrification - Single System	Truck Stop Shore Power
<b>Annual Idling Petroleum Use Externality Costs</b>										
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
<b>Annual Idling GHG Externality Costs</b>										
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
<b>Annual Idling Air Pollutant Externality Costs</b>										
<b>LD Passenger Car Fleet</b>										
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	
<b>HD Combination Long-Haul Truck Fleet</b>										
CO		\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
NOx		\$24	\$17	\$24	\$16	\$108	\$15	\$8	\$8	\$24
PM10		\$2	\$7	\$2	\$1	\$1,313	\$1	\$7	\$1	\$2
PM2.5		\$17	\$14	\$17	\$11	\$329	\$10	\$7	\$6	\$17
VOC		\$3	\$15	\$3	\$2	\$1,798	\$2	\$14	\$1	\$3
SOx		\$11	\$10	\$11	\$8	\$542	\$7	\$6	\$5	\$11
Heavy-Duty Total		\$58	\$63	\$58	\$39	\$4,090	\$36	\$41	\$20	\$58
<b>Total Petroleum, GHG, and Air Pollutant Externality Costs</b>										
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
<b>Total Petroleum, GHG, and Air Pollutant Cost Savings</b>										
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
<b>Annual Operating Savings with Externality Cost Savings</b>										
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	\$28,832
<b>Simple Payback with Externality Costs (years)</b>										
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	0.9

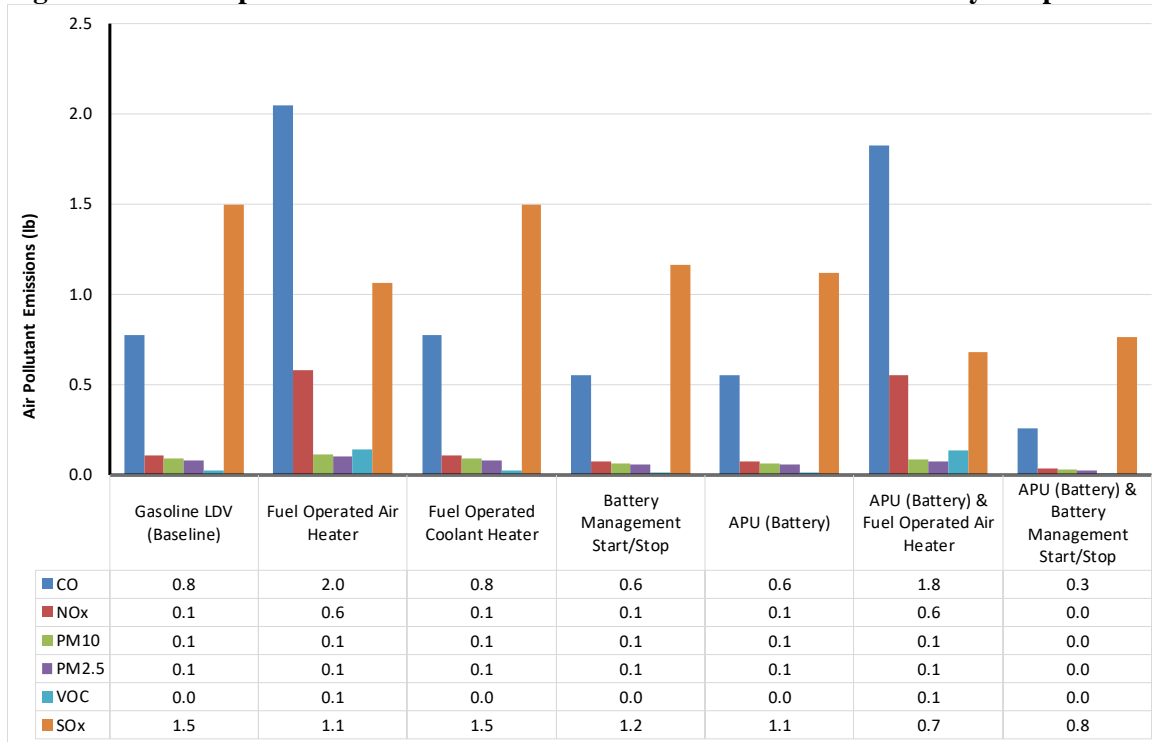
**Figure 49. IR Output Sheet – LDV Simple Payback with and without Externalities Graph**



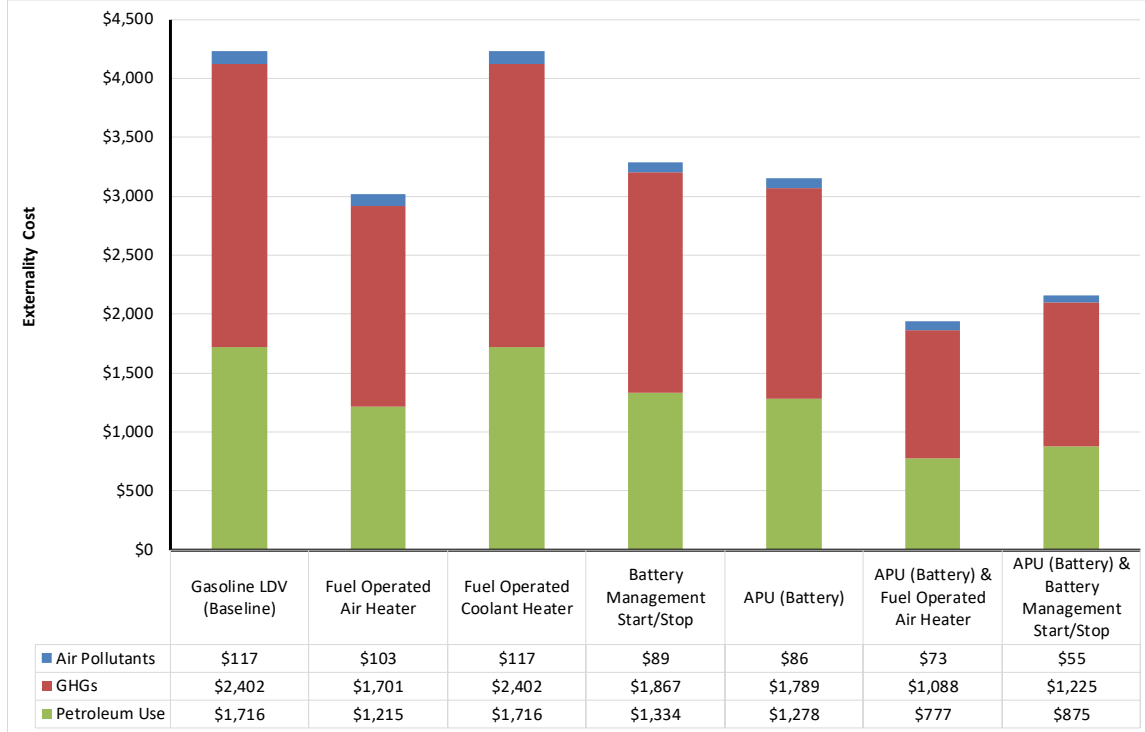
**Figure 50. IR Output Sheet – Annual HDV Energy Use and GHGs Summary Graph**



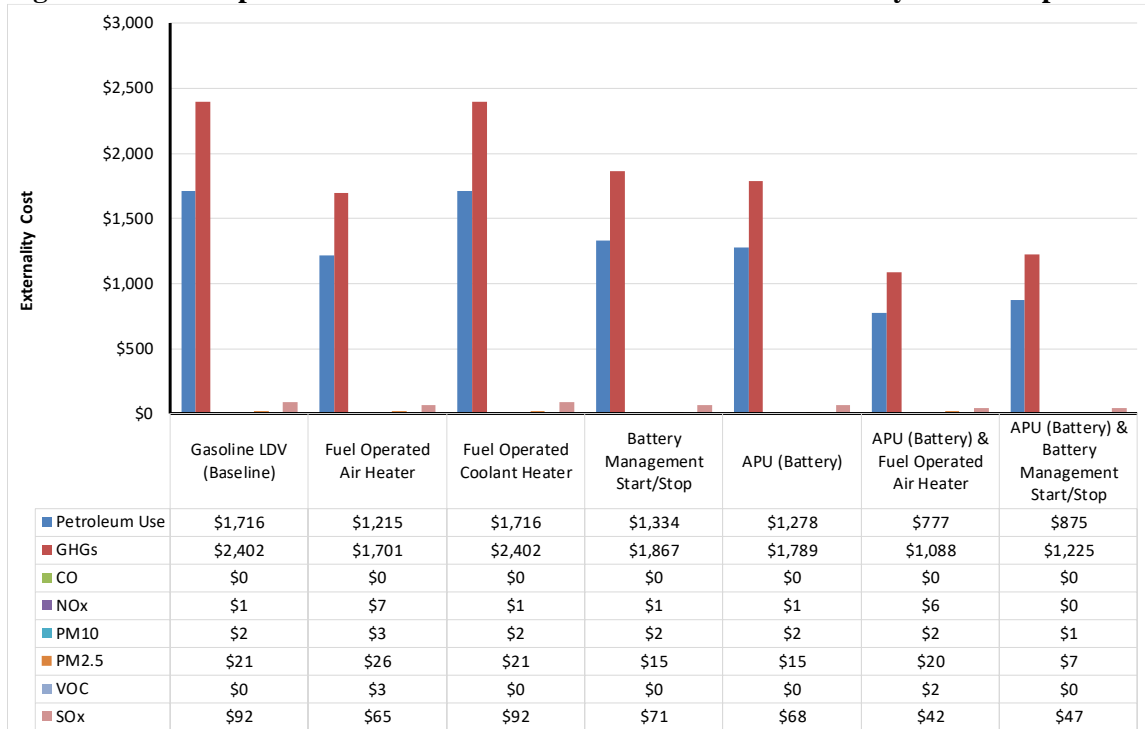
**Figure 51. IR Output Sheet – Annual LDV Air Pollutant Emissions Summary Graph**



**Figure 52. IR Output Sheet – Annual HDV Annual Externality Costs Graph**



**Figure 53. IR Output Sheet – Annual LDV Annual Detailed Externality Costs Graph**



## 2.15 Background Data Sheet

This sheet contains the background data for the Simple Payback, Total Cost of Ownership, On-Road Fleet Footprint, Off-Road Fleet Footprint, Electric Vehicle Charging, and Idle Reduction 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 54) and the IR equipment for on-road vehicles and the Payback AFVs for the off-road equipment (Figure 55). This will alter the lookup tables, which AFLEET Tool references for the default data of key inputs in the various sheets. Figure 56 shows an example of one look up table. Also mentioned previously, the user can input custom electricity mixes on this sheet (Figure 56). 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 54. 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 55. Background Data Sheet - AFLEET Look Up Tables - Equipment Vocation Selection**

Aerial Lifts	Articulating Boom Lift
Agricultural Tractors	Compact Tractor
Airport Support Equipment	Cargo Loader
Chain Saws	Commercial Chain Saw
Commercial Turf Equipment	Zero-Turn Commercial Turf
Cranes	Rubber Tired Gantry
Crawler Tractor/Dozers	Compact Bulldozer
Excavators	Compact Excavator
Forklifts	Warehouse Forklift
Golf Carts	Golf Cart
Lawn & Garden Tractors	Commercial Tractor
Lawn Mowers	Zero-Turn Mower
Leafblowers/Vacuums	Commercial Leafblower
Rollers	Roller
Rubber Tire Loaders	Rubber Tire Loader
Skid Steer Loaders	Skid Steer Loader
Snowblowers	Snowblower
Sweepers/Scrubbers	Sweeper/Scrubber
Terminal Tractors	Terminal Tractor
Tractors/Loaders/Backhoes	Backhoe
Trimmers/Edgers/Brush Cutter	Commercial Trimmer

**Figure 56. Background Data Sheet - AFLEET Look Up Tables - New Vehicle Purchase Price**

		2025 Fuel Costs by Vehicle Type and Fuel Type															
Vocation Type	MOVES Category	Fuel Type															
		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 Hybrid Hydraulic (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	\$90,000					\$140,000	\$137,500		\$100,000	\$100,000			\$165,000	\$150,000	\$190,000
Regional Haul Freight Truck	Combination Short-Haul Truck	\$90,000	\$80,000					\$127,500	\$125,000		\$90,000	\$90,000			\$130,000	\$120,000	\$155,000
Delivery Straight Truck	Single Unit Long-Haul Truck	\$75,000	\$65,000					\$115,000	\$110,000		\$75,000	\$75,000			\$140,000	\$125,000	
Delivery Step Van	Single Unit Short-Haul Truck	\$65,000	\$55,000				\$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 57. Background Data Sheet – GREET Fleet Specifications – Electricity Mix**

			Alaska Systems Coordinating Council (ASCC)	Florida Reliability Coordinating Council (FRCC)	Hawaiian Islands Coordinating Council (HICC)	Midwest Reliability Organization (MRO)	Northeast Power Coordinating Council (NPCC)	Reliability First Corporation (RFC)	SERC Reliability Corporation (SERC)	Southwest Power Pool (SPP)	Texas Regional Entity (TRE)	Western Electricity Coordinating Council (WECC)	User Mix
	U.S. Average 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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