

User Guide for AFLEET Tool 2023

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NOTATION

Acronyms and Abbreviations

AFLEET	Alternative Fuel Life-Cycle Environmental and Economic Transportation
AFV	alternative fuel vehicle
Argonne	Argonne National Laboratory
B100	blend of 100% biodiesel by volume
B20	blend of 20% biodiesel and 80% diesel by volume
CD	charge depleting
CFI	charging and fueling infrastructure
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 ₂	gaseous hydrogen
GHG	greenhouse gas
GREET	Greenhouse gases, Regulated Emissions, and Energy Use in Transportation
HDV	heavy-duty vehicle
HEV	hybrid electric vehicle
HHV	hydraulic hybrid vehicle
IR	idle reduction
LDV	light-duty vehicle
LNG	liquefied natural gas
LPG	liquefied petroleum gas
MOVES	Motor Vehicle Emission Simulator
NO _x	nitrogen oxides

PHEV	plug-in hybrid electric vehicle
PM ₁₀	particulate matter with a diameter of 10 micrometers or less
PM _{2.5}	particulate matter with a diameter of 2.5 micrometers or less
PTW	pump-to-wheels
RD100	blend of 100% renewable diesel by volume
RD20	blend of 20% renewable diesel and 80% diesel by volume
SO _x	sulfur oxides
TBW	tire and brake wear
TCO	total cost of ownership
VOC	volatile organic compound
WTP	well-to-pump
WTW	well-to-wheels

Units of Measure

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

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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 eight calculation methods depending on the user's goals.

The first option is the Simple Payback Calculator, which 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, which evaluates the net present value of operating and fixed costs over the years of planned ownership of a new vehicle, as well as lifetime petroleum use, GHGs, and air pollutant emissions. The third option is the On-Road Fleet Footprint Calculator, which 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, which 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 Charging and Fueling Infrastructure Emissions Calculator, which estimates the annual petroleum use, GHGs, and air pollutant benefits of utilizing public electric vehicle charging and alternative fuel vehicle fueling infrastructure. The sixth option is the EV Utility Rate Calculator, which estimates utility energy, demand, and fixed costs for charging electric vehicles. The seventh option is the EV Charger TCO Calculator, which estimates charger capital costs, charger operating costs, and electricity costs to calculate the lifetime total cost of ownership of an EV charger. 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.



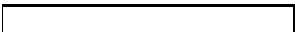
2. DESCRIPTION OF AFLEET TOOL

There are eighteen 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, and Idle Reduction Calculators use the vehicle location for air pollutant calculations, while also IR Calculator uses it for fuel pricing and EV Rate and EV Charger TCO use it for utility calculations.

- **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 2022). Each vehicle type has default vocational data that populate the cells. This information is available in lookup tables on the Background Data sheet. 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) 12 - User Defined (go to 'Background Data' sheet)	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 2022a). 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 2022b).

The vehicle cycle feature was only available for LDVs prior to AFLEET 2023. However, Several HDV types have been added to the GREET vehicle cycle model starting in GREET 2021 (Iyer 2021). Therefore, we have now included vehicle-cycle results for HDVs in AFLEET 2023. We use GREET’s PHEV20, PHEV40 and EV300 results as default for AFLEET 2023’s PHEV, EREV, and EV, respectively. AFLEET has the option to analyze GREET EV200 results. For AFLEET 2023, we generated results for the following light-duty 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).

For HDVs, GREET currently addresses diesel, diesel HEV, EV, and FCV powertrains for three vehicle types: Class 6 Pickup and Delivery, Class 8 Day-cab, and Class 8 Sleeper-cab. Those three GREET vehicle types were mapped to AFLEET’s Combination Long-Haul Truck, Combination Short-Haul Truck, and Single Unit Long-Haul Truck categories, respectively. We generated results for the following heavy-duty vehicle types not included in GREET by default by mapping the following Autonomie vehicle types: Class 6 StepVan Medium, Class 8 Refuse Heavy, Class 8 City Transit Heavy, and Class 7 School Medium to AFLEET’s HDV types: Single Unit Short-Haul Truck, Refuse Truck, Transit Bus, and School Bus, respectively (Islam 2022). In addition, we generated results for the following heavy-duty vehicles not included in GREET by default: gasoline, biodiesel, renewable diesel, E85, LPG, CNG, LNG and LNG diesel pilot ignition. This was done by modifying the vehicle weight using data from Autonomie model results (Islam 2022).

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 2022a). In addition, sulfur oxides (SO_x) were added to AFLEET during a previous update, as it is an important emission from electricity production and is also produced by combusting some vehicle fuels. SO_x emissions for vehicle operation, upstream, and vehicle production are all calculated using GREET co-efficients. MOVES is not used for vehicle operation SO_x, as these emissions can be calculated via a sulfur balance, i.e., amount of sulfur in the fuel directly impacts SO_x emissions.

Recent analyses have found that diesel in-use emissions are much higher than their laboratory certification results (Cai 2017, Anenberg 2017). Diesel NO_x is driven by the type and performance of its aftertreatment systems, which can be highly duty-cycle dependent. For diesel LDVs, high speeds and accelerations may cause higher emissions (Anenberg 2017), while for diesel HDVs long idle times, low speeds, and low loads can cause higher NO_x (Cai 2017). While data for in-use NO_x of new diesels is limited, but analyses have shown that the MOVES2014 model was underestimating diesel NO_x (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_x, however they did not examine LDV diesel NO_x (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_x engine option for CNG and LNG heavy-duty vehicles (Cai 2017). Because of severe air quality concerns in California, CARB adopted optional low NO_x heavy-duty standards. For AFLEET 2019, propane low-NO_x 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-NO_x 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 hoteling 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	<input checked="" type="checkbox"/> Vehicle Heating <input checked="" type="checkbox"/> Engine Heating <input checked="" type="checkbox"/> Cooling <input checked="" type="checkbox"/> Electrical								
% of Idle Hours by Service	33%	0%	33%	34%						
Light-Duty Baseline & IR Equipment										
	Number of Light-Duty Vehicles	Services Provided by IR Equipment				Idling Hour Reduction Goal	Fuel Consumption (GGE/hr)	Electrical Power Demand (W)	IR Equipment Price (\$/Vehicle)	
Gasoline	1					578	0.30			
Fuel Operated Air Heater	1	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	0	0.03	0	\$900	
Fuel Operated Coolant Heater	1	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	0	0.08	0	\$1,250	
Battery Management Start/Stop	1	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	595	0.00	250	\$1,500	
APU (Battery)	1	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	1173	0.00	250	\$4,300	
APU (Battery) & Fuel Operated Air Heater	1	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	1750	0.03	250	\$5,200	
APU (Battery) & Battery Management Start/Stop	1	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	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	<input checked="" type="checkbox"/> Vehicle Heating <input checked="" type="checkbox"/> Engine Heating <input checked="" type="checkbox"/> Cooling <input checked="" type="checkbox"/> Electrical								
% of Idle Hours by Service	33%	0%	33%	34%						
Annual Hotelling Hours (per Vehicle)*	0	<input checked="" type="checkbox"/> Vehicle Heating <input checked="" type="checkbox"/> Engine Heating <input checked="" type="checkbox"/> Cooling <input checked="" type="checkbox"/> Electrical								
% of Hotelling Hours by Service	33%	0%	33%	34%						
Heavy-Duty Baseline & IR Equipment										
	Number of Heavy-Duty Vehicles	Services Provided by IR Equipment				Conventional Idling Hour Reduction Goal	Hotelling Hour Reduction Goal	Fuel Consumption (DGE/hr)	Electrical Power Demand (W)	IR Equipment Price (\$/Vehicle)
Diesel	1						0.75			
Diesel (Hotelling)*	1	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	66	0	0.06	0	\$1,800
Fuel Operated Air Heater	1	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	0	0	0.12	0	\$1,700
Fuel Operated Coolant Heater	1	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	68	0	0.00	1,300	\$2,500
Battery Management Start/Stop	1	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	200	0	0.20	0	\$10,000
APU (Diesel)	1	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	134	0	0.00	1,300	\$8,000
APU (Battery)	1	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	200	0	0.06	1,300	\$9,800
APU (Battery) & Fuel Operated Air Heater	1	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	134	0	0.00	1,300	\$10,500
APU (Battery) & Battery Management Start/Stop	1	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	134	0	0.00	0	\$0
Truck Stop Electrification - Single System	1	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	134	0	0.00	1,300	\$2,500
Shore Power	1	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	134	0	0.00	1,300	\$2,500

Argonne has provided default data for many inputs in AFLEET Tool; however, it is highly recommended that users enter their own data whenever possible. 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 AFLEETs 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 2023, the Electric Vehicle Charging Calculator was updated to include calculations for alternative fuels and renamed as the Charging and Fueling Infrastructure (CFI) Emissions Calculator. The previous structure of the Electric Vehicle Charging Calculator was retained to examine Level 2 and DC Fast Charging Infrastructure; its 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.**

The essential user inputs to examine alternative fuel station emission the user inputs (Figure 7), in addition to those mentioned previously (vehicle location) are:

- **number of stations**
- **annual fuel consumption**
- **light-duty vehicle utilization %**
- **heavy-duty vehicle utilization %.**

Figure 7. Inputs Sheet – Charging and Fueling Infrastructure Emissions Inputs

Level 2 Charging Infrastructure					
Predicted Weekly Utilization	Moderate				
Venue	Number of Chargers	Weekly Utilization (sessions/week/charger)	Average Session Power (kW)	Charge Time (minutes/session)	
Parking Lot	0	4.5	4	150	
Retail & Leisure	0	5.5	4	90	
Education	0	6.0	4	150	
Healthcare	0	6.5	4	150	
Workplace	0	4.5	4	150	
Multi-Unit Dwelling	0	3.0	4	210	
Single-Unit Dwelling	0	6.0	4	120	

DC Fast Charging Infrastructure					
Predicted Weekly Utilization	Moderate				
Venue	Number of Chargers	Weekly Utilization (sessions/week/charger)	Average Session Power (kW)	Charge Time (minutes/session)	
Parking Lot	0	15.0	24	22	
Retail & Leisure	0	15.0	24	22	
Education	0	15.0	24	22	
Healthcare	0	15.0	24	22	
Workplace	0	15.0	24	22	
Multi-Unit Dwelling	0	15.0	24	22	
Single-Unit Dwelling	0	15.0	24	22	

AFV Fueling Infrastructure					
Predicted Weekly Utilization	Moderate				
Station Type	Number of Stations	Annual Fuel Consumption (fuel unit/station)	Fuel Unit	Light-Duty Vehicle Utilization %	Heavy-Duty Vehicle Utilization %
Level 2 EVSE	0	6,000	kWh	100%	0%
DCFC EVSE	0	28,000	kWh	100%	0%
Hydrogen	0	28,000	hydrogen kg	100%	0%
B20	0	52,000	B20 gallon	0%	100%
B100	0	52,000	B100 gallon	0%	100%
RD20	0	52,000	RD20 gallon	0%	100%
RD100	0	52,000	RD100 gallon	0%	100%
E85	0	217,000	E85 gallon	100%	0%
Propane	0	11,000	LPG gallon	0%	100%
CNG	0	245,000	CNG GGE	0%	100%
LNG	0	163,000	LNG gallon	0%	100%

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 or stations to be analyzed as the default is set to zero. The Charging and Fueling Infrastructure Emissions estimates the annual petroleum use, GHGs, and air pollutant benefits of utilizing public electric vehicle level 2 and DC fast charging infrastructure and AFV

fueling infrastructure. Unlike other calculators in AFLEET, the Charging and Fueling Infrastructure Emissions Calculator output is the benefit of utilizing a charger/station and not actual emission impacts of the charger/station.

The benefit for public electric vehicle level 2 and DC fast charging infrastructure 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 CFI 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.**

Similarly, the benefit for AFV fueling infrastructure is calculated by the user entering utilization for each station type and the percentage of vehicle types utilizing the station: light-duty vs. heavy-duty. A detailed breakdown of vehicle types can be edited in the Background Data sheet and can be accessed via hyperlink. In addition, we provide default annual fuel consumption with a “moderate” level value provided by default, 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 data from California Energy Commission (2023). The AFV station types in AFLEET are:

- **Level 2 EVSE**
- **DCFC EVSE**
- **Hydrogen**
- **B20**
- **B100**
- **RD20**
- **RD100**
- **E85**
- **Propane**
- **CNG**
- **liquefied natural gas (LNG).**

The utilization data is used to calculate the fuel dispensed by each charger/station. The amount of AFV miles is estimated using a weighted AFV efficiency and the amount of fuel dispensed. The energy use and emissions are then estimated for the AFV mileage dispensed by

the charger/station. A counterfactual, of those miles driven by conventional gasoline and diesel light-duty and heavy-duty vehicle mix instead of an AFV is used to estimate the baseline emissions. Therefore, the energy and emissions are estimated for a gasoline and diesel vehicle mix driving the same mileage as dispensed by the charger/station. The CFI emissions benefit is equal to the AFV emissions subtracted from gasoline and diesel vehicle mix 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.

In AFLEET 2023, the EV Charger TCO Calculator was added to the tool. The EV Charger TCO Calculator estimates the lifetime total cost of ownership of an EV charger. The structure of this tool was originally developed for a New York State Clean Transportation Roadmap to examine charger capital costs, charger operating costs, and electricity costs (Levinson 2021). The essential user inputs (Figure 9) for the chargers, in addition to those mentioned previously (vehicle location) are:

- **number of chargers**
- **charger rating**
- **utilization**
- **charge time**
- **charger cost**
- **charger incentive**
- **infrastructure cost**
- **infrastructure incentive.**

There are several charger types and use types in AFLEET:

- **residential level 1: light-duty vehicle**
- **residential level 2: light-duty vehicle**
- **publicly accessible level 2: light-duty vehicle**
- **publicly accessible DCFC: 50-100 kW: all vehicles**
- **publicly accessible DCFC: 100-300 kW: all vehicles**
- **publicly accessible DCFC: 300+ kW: all vehicles**
- **fleet level 2**
- **fleet DCFC: 50-100 kW**
- **fleet DCFC: 100-300 kW**
- **fleet DCFC: 300+ kW.**

The above four fleet charger types are selected via a dropdown list and cover the following vehicle types:

- **transit bus**
- **refuse truck**
- **single unit short-haul truck**
- **single unit long-haul truck**
- **combination short-haul truck**
- **combination long-haul truck.**

There are additional charger assumptions that the user can modify (Figure 9):

- **warranty cost**
- **maintenance cost**
- **communications cost**
- **host site access cost**
- **charger lifetime**

- **infrastructure lifetime**
- **discount factor.**

The user can define rates for each charger types (e.g. residential level 1 vs. residential level 2) via hyperlink to the EV Charger TCO Calculator sheet. For ease of use, the user can select up to three different utility rates for the three main charger type categories on the Inputs sheet:

- **residential**
- **publicly accessible**
- **fleet.**

The key features to modify the utility rate scenarios are done via dropdowns in the Utility Rate Inputs section are:

- **state** (by default it is linked to Primary Vehicle Location dropdown, but the user can select different states in this section)
- **rate type**
 - **residential:** rate that applies to residential customers
 - **commercial:** rate that applies business customers
 - **custom:** user defined rate that can be entered on Background Data sheet
- **rate structure**
 - **flat:** rate structure where the energy and demand charges do not change over time of day (e.g., they are always off-peak).
 - **TOU (time-of-use):** rate structure where the energy and demand charges change over time of day. AFLEET uses three TOU periods, as this is the typical structure for utilities. In some cases, all three are used in a rate, while in others only off-peak and on-peak are used.
 - **off-peak:** period when electricity demand is lowest during the day; lowest cost per kWh/kW
 - **mid-peak:** period when electricity demand is neither at its lowest or highest point during the day; an intermediary amount is paid per kWh/kW
 - **on-peak:** period when electricity demand is highest during the day; lowest cost per kWh/kW
 - **EV:** rate structure designed by utility specifically for EV charging
- **utility rate name (utility “common name” + rate name + rate structure + demand limit)**
 - **demand limit:** minimum and maximum kW for which the rate is applicable (e.g. if your max demand is 60 kW and the rate is for 50 kW or less, you would not be eligible to use that rate)
- **charging strategy**
 - **managed:** To reduce demand charges, users selecting “managed charging” will have the charger power throttled down to the minimum power required to charge the vehicle during the charging period
 - **unmanaged:** charger will operate at full power
- **charging period: start time** (charging starts at this time)
- **charging period: end time** (If using managed strategy, charging will end at this time. When using unmanaged charging, charging can finish before this time based on charger

rating and amount of energy to be dispensed. Make sure charging period is long enough or charger rating is high enough to meet the needed energy to be dispensed. EV Rate Calculator gives a warning, though we do not have a warning for EV Charger TCO).

Figure 9. Inputs Sheet – EV Charger TCO Inputs

Key Inputs									
Fleet Charger Type		Fleet DCFC: 50-100 kW							
Charger Type	Use Type	Number of Chargers	Charger Rating (kW)	Utilization (sessions/week/charger)	Charge Time (hr/session)	Charger Cost (\$/charger)	Charger Incentive (\$/charger)	Infrastructure Cost (\$/charger)	Infrastructure Incentive (% of costs)
Residential Level 1	Light-Duty Vehicle	1	1.9	6	8.5	\$380	\$0	\$0	0%
Residential Level 2	Light-Duty Vehicle	1	7.7	6	2.1	\$689	\$0	\$480	0%
Publicly Accessible Level 2	Light-Duty Vehicle	1	16.8	5	1.0	\$4,900	\$0	\$7,000	0%
Publicly Accessible DCFC: 50-100 kW	All Vehicles	1	50	15	0.3	\$27,900	\$0	\$62,700	0%
Publicly Accessible DCFC: 100-300 kW	All Vehicles	1	150	26	0.1	\$87,800	\$0	\$75,500	0%
Publicly Accessible DCFC: 300+ kW	All Vehicles	1	350	26	0.0	\$139,000	\$0	\$138,200	0%
Fleet DCFC: 50-100 kW	School Bus	1	50	6	1.7	\$27,900	\$0	\$62,700	0%
Fleet DCFC: 50-100 kW	Transit Bus	1	50	6	6.4	\$27,900	\$0	\$62,700	0%
Fleet DCFC: 50-100 kW	Refuse Truck	1	50	6	3.5	\$27,900	\$0	\$62,700	0%
Fleet DCFC: 50-100 kW	Single Unit Short-Haul Truck	1	50	6	1.0	\$27,900	\$0	\$62,700	0%
Fleet DCFC: 50-100 kW	Single Unit Long-Haul Truck	1	50	6	1.9	\$27,900	\$0	\$62,700	0%
Fleet DCFC: 50-100 kW	Combination Short-Haul Truck	1	50	6	8.9	\$27,900	\$0	\$62,700	0%
Fleet DCFC: 50-100 kW	Combination Long-Haul Truck	1	50	6	22.2	\$27,900	\$0	\$62,700	0%

Additional Inputs				
		Residential	Publicly Accessible	Fleet
Warranty	% of equipment cost	0.0%	7.0%	7.0%
Maintenance	% of equipment cost	0.0%	0.5%	0.5%
Communications	\$/yr/charger	\$0	\$255	\$255
Host site access	\$/yr/charger	\$0	\$500	\$0
Charger Lifetime	years		15	
Infrastructure Lifetime	years		50	
Discount Factor	%		1.89%	

Utility Rate Inputs									
Charger Location	Rate Number	State	Rate Type	Rate Structure	Utility Rate Name	Charging Strategy	Start Time	Charging Period:	End Time:
Residential	1	VIRGINIA	Residential	Flat	Appalachian Power: Residential Service (Standard) (Flat)	Unmanaged	12:00 AM		12:00 AM
Residential	2	VIRGINIA	Residential	TOU	Appalachian Power: Residential Service (Standard) Time-of-Day (TOU)	Unmanaged	12:00 AM		12:00 AM
Residential	3	VIRGINIA	Residential	EV	Dominion Energy: 1EV Residential Service with Electric Vehicle Charging	Unmanaged	12:00 AM		12:00 AM
Publicly Accessible	1	VIRGINIA	Commercial	Flat	Appalachian Power: General Service (Standard) Primary Voltage (Flat, 25-1000 kW)	Unmanaged	7:00 PM		3:00 AM
Publicly Accessible	2	VIRGINIA	Commercial	TOU	Appalachian Power: General Service (Standard) Primary Voltage Time-of-Day (TOU)	Unmanaged	7:00 PM		3:00 AM
Publicly Accessible	3	VIRGINIA	Commercial	EV		Unmanaged	7:00 PM		3:00 AM
Fleet	1	VIRGINIA	Commercial	Flat	Appalachian Power: General Service (Standard) Primary Voltage (Flat, 25-1000 kW)	Unmanaged	10:00 PM		6:00 AM
Fleet	2	VIRGINIA	Commercial	TOU	Appalachian Power: General Service (Standard) Primary Voltage Time-of-Day (TOU)	Unmanaged	10:00 PM		6:00 AM
Fleet	3	VIRGINIA	Commercial	EV		Unmanaged	10:00 PM		6:00 AM

2.3 Payback Sheet

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

- **carbon monoxide (CO)** from tailpipe
- **nitrogen oxides (NO_x)** from tailpipe
- **particulate matter with a diameter of 10 micrometers or less (PM₁₀)** from tailpipe and tire and brake wear (TBW)
- **particulate matter with a diameter of 2.5 micrometers or less (PM_{2.5})** from tailpipe and TBW
- **VOCs (volatile organic compounds)** from tailpipe and evaporation
- **Sulfur oxides (SO_x)** 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 10). 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 10. Payback Sheet – LDVs, HDVs, Small Equipment, and Large Equipment Inputs

	Gasoline	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
On-Road Vehicle Inputs																	
Light-Duty Vehicle Inputs																	
Vehicle Type	Passenger Car																
Number of LDVs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	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	
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	
Heavy-Duty Vehicle Inputs																	
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	\$0.935
Small Equipment Inputs																	
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	0	0	1,364	0	0	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	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 %)																	
DEF Use (% of fuel consumption)	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	
Incentive (\$/unit)	\$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	
Large Equipment Inputs																	
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	0	0	0	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 an LNG / diesel pilot ignition vehicle is set to match the performance of the Westport™ high-pressure direct injection system, though other systems will have different performance. Some vehicles use selective catalytic reduction systems to reduce NO_x emissions. These systems require DEF, a urea-based solution, to operate correctly. DEF use is typically estimated as a percent of fuel consumption; users can adjust this value on this sheet. A vehicle purchase incentive can be entered on this sheet or can be included in the purchase price on the Inputs sheet.

On the Inputs sheet, the user can select whether to examine fuel price sensitivity via dropdown box. On the Payback sheet, the user can enter the values for the high and low fuel price scenarios either by percentage of default GGE or by directly entering the values on a GGE basis (Figure 11).

Figure 11. Payback Sheet – Fuel Price Sensitivity

	Gasoline	Diesel	Gasoline HEV	Gasoline PHEV	Gasoline EREV	EV	G.H2 FCV	Diesel HEV	Diesel HHV	B20	B100	E85	LPG	CNG	LNG	LNG / Diesel Pilot Ignition
Fuel Price Sensitivity																
Public Fuel Price Sensitivity Case																
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
Private Fuel Price Sensitivity Case																
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 12). 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 12. Payback Sheet – Infrastructure Costs

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

The other tables in this sheet include the calculation for simple payback, petroleum use, GHG emissions, air pollutant emissions, and externality costs. The calculation for simple payback is based on the acquisition and annual operating costs for a new AFV as compared to its conventional counterpart. Specifically, calculating the years (and miles) needed for the operating savings to payback the higher incremental acquisition cost. In cases where the operating costs for the AFV are higher than the costs of the conventional vehicle, there will be no payback calculated. 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 2023 for AFLEET Tool 2023). 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 2022a). 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 SO₂, VOC, NO_x, PM_{2.5}, PM₁₀, and NH₃ emissions (Jaramillo and Muller 2016, Muller 2017). From this model, we use the VOC, NO_x, PM_{2.5}, and PM₁₀ 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 13-15), 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 16-20). 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 13. 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
Acquisition Cost															
Light-Duty (LD) Fleet & Infrastructure	\$1,000,000		\$1,150,000		\$1,700,000	\$1,500,000	\$2,925,000				\$1,125,000		\$1,300,000	\$1,350,000	
Heavy-Duty (HD) Fleet & Infrastructure		\$10,500,000				\$33,500,000			\$12,500,000	\$10,500,000				\$13,000,000	
Annual Operating Cost - Private Station Fueling															
LD Fleet & Infrastructure	\$149,239		\$128,902		\$118,410	\$112,476	\$153,246				\$194,020		\$162,875	\$132,515	
HD Fleet & Infrastructure		\$5,473,171			\$4,824,318			\$4,952,290	\$6,653,558				\$5,197,884		
Incremental Acquisition Cost - Private Station Fueling															
Compared to Gasoline LD Fleet			\$150,000		\$700,720	\$500,027	\$1,925,000				\$125,000		\$300,000	\$350,000	
Compared to Diesel HD Fleet						\$23,001,173		\$2,000,000		\$0			\$2,500,000		
Annual Operating Savings - Private Station Fueling															
Compared to Gasoline LD Fleet			\$20,337		\$30,829	\$36,763	-\$4,007				-\$44,781		-\$13,637	\$16,724	
Compared to Diesel HD Fleet						\$648,853		\$520,881		-\$1,180,387			\$275,287		
Simple Payback (years) - Private Station Fueling															
LD Passenger Car Fleet			7.4		22.7	13.6	No payback			No payback		No payback	No payback	20.9	
LD High Fuel Price Sensitivity			6.3		17.7	10.5	284.9			No payback		No payback	No payback	12.7	
LD Low Fuel Price Sensitivity			8.9		31.7	19.2	No payback			No payback		No payback	No payback	58.7	
HD Refuse Truck Fleet						35.4			3.8	No payback		No payback		9.1	
HD High Fuel Price Sensitivity						22.1			3.3	No payback		No payback		3.8	
HD Low Fuel Price Sensitivity						88.9			4.6	No payback		No payback		No payback	

Figure 14. 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
Annual Life-Cycle Petroleum Use (barrels)															
LD Petroleum Use	449.4		321.0		93.6	6.1	2.9				17.1		150.5	2.4	
HD Petroleum Use		16,928.0				266.7			13,119.2		742.1			97.5	
Annual Life-Cycle Greenhouse Gas Emissions (short tons)															
LD GHG Emissions	253.3		181.0		144.5	145.0	170.2				56.2		222.9	225.4	
HD GHG Emissions		9,278.7				6,303.0			7,191.0		2,442.0			9,128.4	
Vehicle Operation Air Pollutant Emissions (lb)															
LD Passenger Car Fleet															
CO	2,424.6		1,816.3		518.0	0.0	0.0				3,248.1		2,532.4	1,754.8	
NOx	101.0		65.0		18.5	0.0	0.0				200.3		104.6	84.4	
PM10	33.3		33.3		28.3	26.2	26.2				30.5		33.3	33.3	
PM2.5	12.1		12.1		8.4	6.9	6.9				11.3		12.1	12.1	
VOC	129.8		99.4		28.3	0.0	0.0				62.3		145.0	73.0	
HD Refuse Truck Fleet															
CO		1,640.9				0.0			1,640.9		1,640.9			21,331.7	
NOx		4,232.0				0.0			4,232.0		4,232.0			2,962.4	
PM10		394.4				309.5			394.4		394.4			394.4	
PM2.5		161.1				80.0			161.1		161.1			161.1	
VOC		259.2				0.0			259.2		259.2			880.9	

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

Figure 16. Payback Output Sheet – LDV Simple Payback with and without Externalities Graph

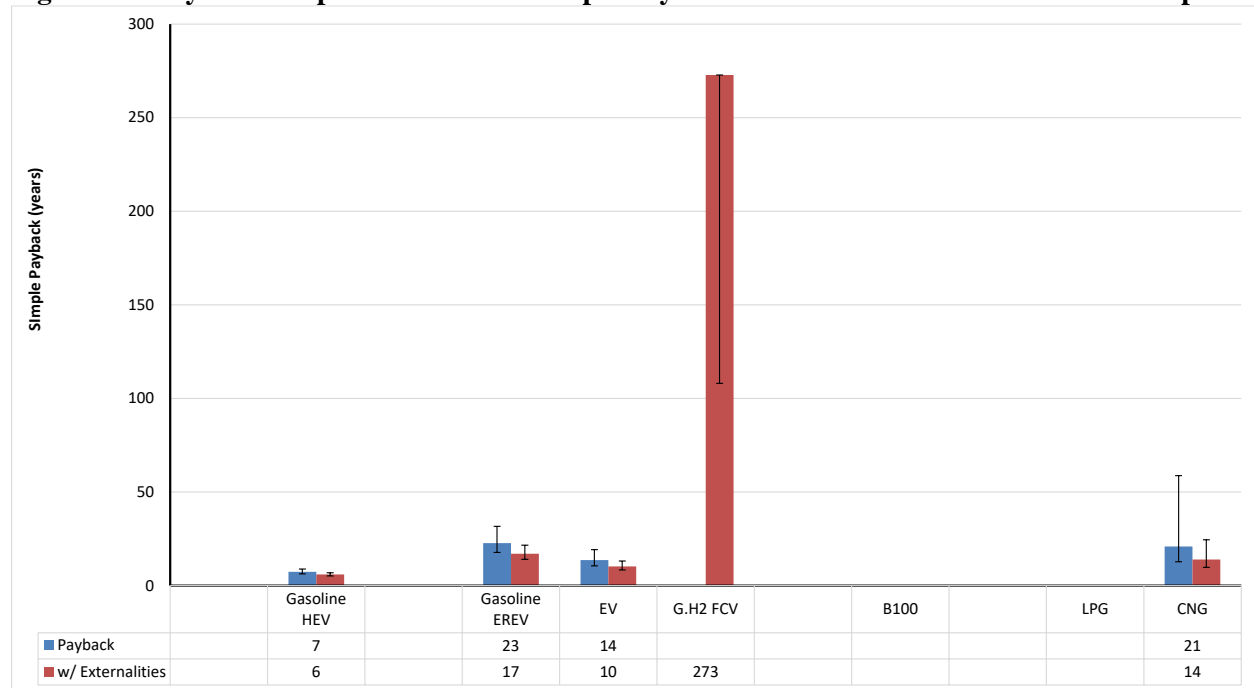


Figure 17. Payback Output Sheet – Annual HDV Energy Use and GHGs Summary Graph

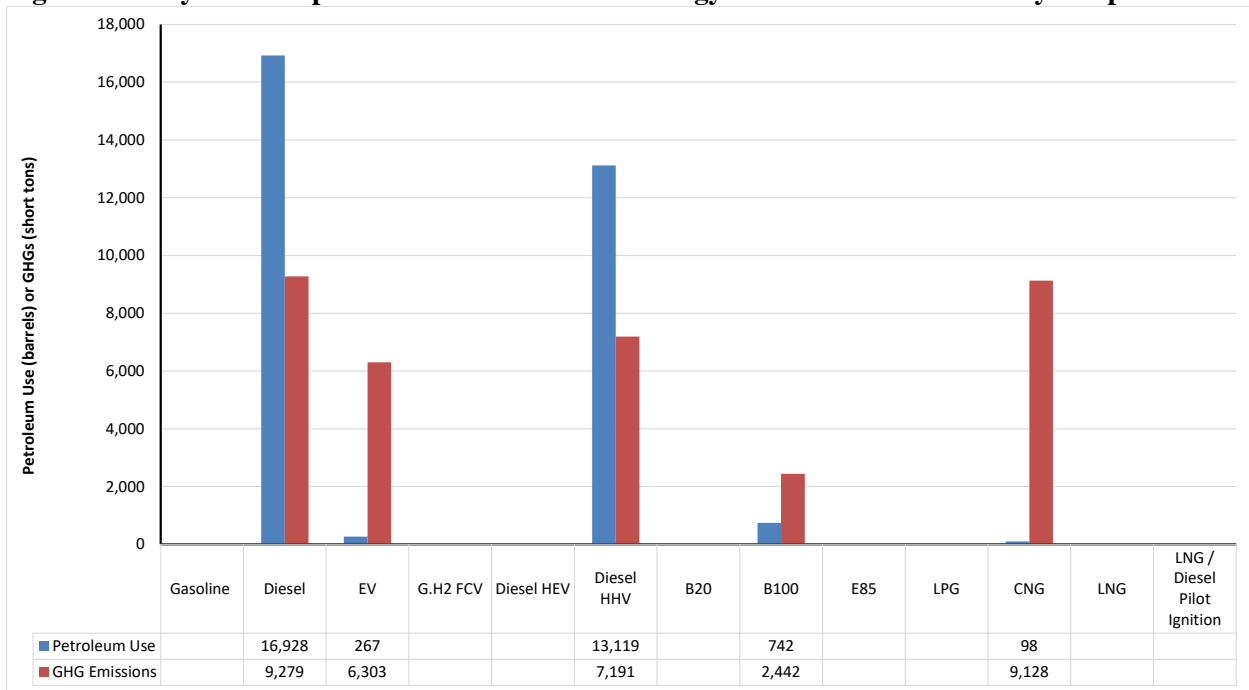


Figure 18. Payback Output Sheet – Annual LDV Air Pollutant Emissions Summary Graph

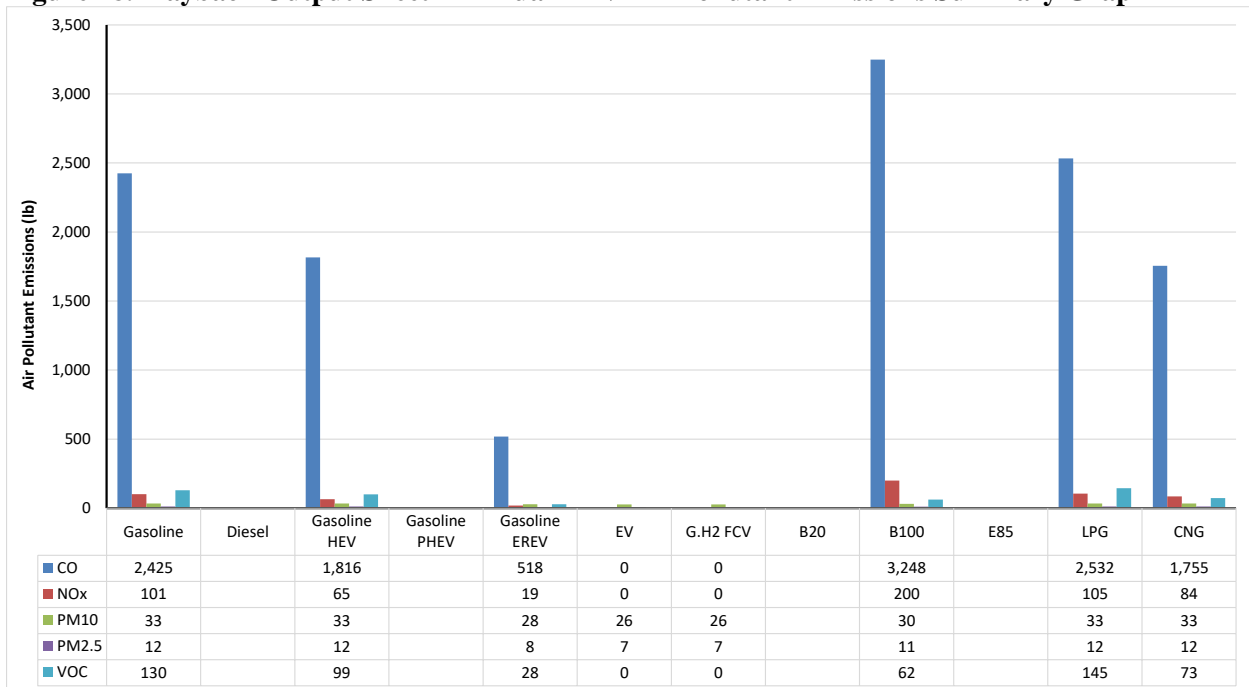


Figure 19. Payback Output Sheet – Annual HDV Annual Externality Costs Graph

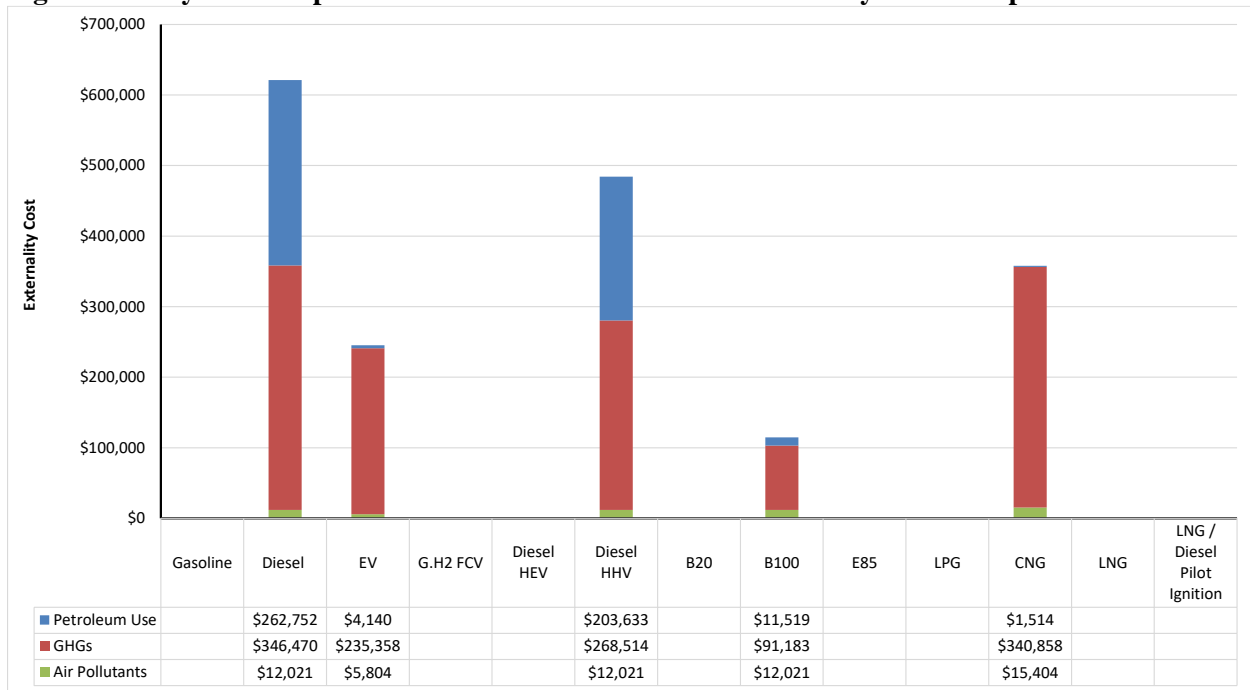


Figure 20. Payback Output Sheet – Annual LDV Annual Detailed Externality Costs Graph



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 13-20).

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 21), 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 21, 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 22). 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 21. TCO Sheet – LDV Characteristics and Cost Calculations

Total Cost of Ownership Calculator

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

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

Total Cost of Ownership Calculator		Project Year				
Annual Gasoline Passenger Car Fleet Petroleum Use, GHGs, and Air Pollutants		1	2	3	4	5
Well-to-Wheels Petroleum and GHGs						
LD Petroleum Use	barrels/year	98.7	98.7	98.7	98.7	98.7
LD GHGs	short ton/year	57.5	57.5	57.5	57.5	57.5
Vehicle Production Petroleum and GHGs						
LD Petroleum Use	barrels/year	0.0	0.0	0.0	0.0	0.0
LD GHGs	short ton/year	0.0	0.0	0.0	0.0	0.0
Vehicle Operation Air Pollutants						
CO	lb/year	226.5	227.8	228.7	391.2	393.7
NOx	lb/year	12.8	12.8	13.0	19.0	19.0
PM10	lb/year	0.8	0.8	0.8	0.8	0.8
PM10 (TBW)	lb/year	9.6	9.6	9.6	9.6	9.6
PM2.5	lb/year	0.5	0.5	0.5	0.7	0.7
PM2.5 (TBW)	lb/year	1.4	1.4	1.4	1.4	1.4
VOC	lb/year	13.0	13.4	13.8	19.1	19.5
VOC (Evap)	lb/year	8.5	8.5	8.5	8.5	8.5
SOx	lb/year	1.4	1.4	1.4	1.4	1.4
Upstream Air Pollutants						
CO	lb/year	0.0	0.0	0.0	0.0	0.0
NOx	lb/year	0.0	0.0	0.0	0.0	0.0
PM10	lb/year	0.0	0.0	0.0	0.0	0.0
PM10 (TBW)	lb/year	0.0	0.0	0.0	0.0	0.0
PM2.5	lb/year	0.0	0.0	0.0	0.0	0.0
PM2.5 (TBW)	lb/year	0.0	0.0	0.0	0.0	0.0
VOC	lb/year	0.0	0.0	0.0	0.0	0.0
VOC (Evap)	lb/year	0.0	0.0	0.0	0.0	0.0
SOx	lb/year	0.0	0.0	0.0	0.0	0.0
Vehicle Production Air Pollutants						
CO	lb/year	0.0	0.0	0.0	0.0	0.0
NOx	lb/year	0.0	0.0	0.0	0.0	0.0
PM10	lb/year	0.0	0.0	0.0	0.0	0.0
PM10 (TBW)	lb/year	0.0	0.0	0.0	0.0	0.0
PM2.5	lb/year	0.0	0.0	0.0	0.0	0.0
PM2.5 (TBW)	lb/year	0.0	0.0	0.0	0.0	0.0
VOC	lb/year	0.0	0.0	0.0	0.0	0.0
VOC (Evap)	lb/year	0.0	0.0	0.0	0.0	0.0
SOx	lb/year	0.0	0.0	0.0	0.0	0.0
Annual Gasoline Passenger Car Fleet Petroleum Use, GHG, and Air Pollutant Externality Costs						
Well-to-Wheels Petroleum and GHG Externality Costs						
Petroleum Use	\$/year	\$1,552	\$1,589	\$1,627	\$1,666	\$1,706
GHGs	\$/year	\$2,172	\$2,225	\$2,278	\$2,333	\$2,389
Vehicle Production Petroleum and GHG Externality Costs						
LD Petroleum Use	\$/year	\$0	\$0	\$0	\$0	\$0
LD GHGs	\$/year	\$0	\$0	\$0	\$0	\$0
Vehicle Emissions Air Pollutant Externality Costs						
CO	\$/year	\$0	\$0	\$0	\$0	\$0
NOx	\$/year	\$147	\$150	\$157	\$235	\$240
PM10	\$/year	\$7	\$7	\$7	\$1	\$1
PM10 (TBW)	\$/year	\$203	\$208	\$213	\$218	\$223
PM2.5	\$/year	\$127	\$130	\$133	\$205	\$210
PM2.5 (TBW)	\$/year	\$353	\$362	\$370	\$379	\$388
VOC	\$/year	\$235	\$248	\$262	\$371	\$387
VOC (Evap)	\$/year	\$153	\$156	\$160	\$164	\$168
SOx	\$/year	\$83	\$85	\$87	\$89	\$91
Upstream Air Pollutant Externality Costs						
CO	\$/year	\$0	\$0	\$0	\$0	\$0
NOx	\$/year	\$0	\$0	\$0	\$0	\$0
PM10	\$/year	\$0	\$0	\$0	\$0	\$0
PM10 (TBW)	\$/year	\$0	\$0	\$0	\$0	\$0
PM2.5	\$/year	\$0	\$0	\$0	\$0	\$0
PM2.5 (TBW)	\$/year	\$0	\$0	\$0	\$0	\$0
VOC	\$/year	\$0	\$0	\$0	\$0	\$0
VOC (Evap)	\$/year	\$0	\$0	\$0	\$0	\$0
SOx	\$/year	\$0	\$0	\$0	\$0	\$0
Vehicle Production Air Pollutant Externality Costs						
CO	\$/year	\$0	\$0	\$0	\$0	\$0
NOx	\$/year	\$0	\$0	\$0	\$0	\$0
PM10	\$/year	\$0	\$0	\$0	\$0	\$0
PM10 (TBW)	\$/year	\$0	\$0	\$0	\$0	\$0
PM2.5	\$/year	\$0	\$0	\$0	\$0	\$0
PM2.5 (TBW)	\$/year	\$0	\$0	\$0	\$0	\$0
VOC	\$/year	\$0	\$0	\$0	\$0	\$0
VOC (Evap)	\$/year	\$0	\$0	\$0	\$0	\$0
SOx	\$/year	\$0	\$0	\$0	\$0	\$0
Total Petroleum Use, GHGs, and Air Pollutants & Externality Costs - Per Lifetime Ownership of Gasoline Passenger Car Fleet						
Petroleum Use	barrels	1,481				\$27,626
GHGs	short tons	862				\$38,675
CO	pounds	6,986				\$0
NOx	pounds	383				\$5,402
PM10	pounds	162				\$3,730
PM2.5	pounds	35				\$10,817
VOC	pounds	563				\$12,433
SOx	pounds	20				\$1,480

2.7 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 23-25), both LDVs and HDVs are included, while LDVs and HDVs are presented separately in the graphs (Figures 26-33). This sheet has additional cost graphs as compared to the Payback Output sheet. Specifically, the cumulative cost of ownership compared to a conventional counterpart (Figure 26) 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 externality 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 23. 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
Light-Duty Passenger Car Fleet and Infrastructure																
Financing	\$102,184		\$117,512		\$173,713	\$153,276	\$298,889			\$114,957			\$132,840	\$137,949		
Depreciation	\$817,574		\$940,210		\$1,390,362	\$1,226,379	\$2,391,403			\$919,771			\$1,062,846	\$1,103,725		
Fuel	\$649,636		\$464,026		\$375,042	\$628,176	\$804,483			\$803,363			\$796,953	\$472,525		
Diesel Exhaust Fluid	\$0		\$0		\$0	\$0	\$0			\$10,688			\$0	\$0		
Maintenance and Repair	\$945,364		\$821,422		\$897,446	\$832,997	\$832,997			\$1,274,465			\$945,364	\$945,364		
Insurance	\$532,774		\$532,774		\$532,774	\$532,774	\$532,774			\$532,774			\$532,774	\$532,774		
License and Registration	\$57,677		\$57,677		\$57,677	\$57,677	\$57,677			\$57,677			\$57,677	\$57,677		
Total Cost of Ownership	\$3,105,209		\$2,933,620		\$3,427,014	\$3,431,279	\$4,918,223			\$3,713,694			\$3,528,453	\$3,250,013		
Heavy-Duty Refuse Truck Fleet and Infrastructure																
Financing		\$1,072,935			\$3,423,173		\$1,277,304		\$1,072,935					\$1,328,396		
Depreciation		\$8,584,525			\$27,389,516		\$10,219,673		\$8,584,525					\$10,628,460		
Fuel		\$22,157,108			\$16,470,132		\$18,241,779		\$34,929,186					\$19,134,852		
Diesel Exhaust Fluid		\$464,704			\$0		\$360,145		\$464,704					\$0		
Maintenance and Repair		\$36,288,112			\$35,509,715		\$35,748,256		\$36,288,112					\$36,476,433		
Insurance		\$2,750,786			\$2,750,786		\$2,750,786		\$2,750,786					\$2,750,786		
License and Registration		\$289,726			\$289,726		\$289,726		\$289,726					\$289,726		
Total Cost of Ownership		\$71,607,894			\$85,833,048		\$68,887,668		\$84,379,972					\$70,608,652		

Figure 24. 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
Lifetime Life-Cycle Petroleum Use (barrels)																
LD Petroleum Use	4,494		3,210		936	102	29						1,505	24		
HD Petroleum Use		169,280				2,667			131,192					975		
Lifetime Life-Cycle Greenhouse Gas Emissions (short tons)																
LD GHG Emissions	2,533		1,810		1,445	2,404	1,702						2,229	2,254		
HD GHG Emissions		92,787				63,030			71,910				24,420	91,284		
Lifetime Vehicle Operation Air Pollutant Emissions (lb)																
Light-Duty Passenger Car Fleet																
CO	25,032		18,752		5,348	0	0						34,052	26,144	18,117	
NOx	1,147		739		211	0	0						2,175	1,189	959	
PM10	343		343		285	262	262						310	343	343	
PM2.5	128		128		86	69	69						119	128	128	
VOC	1,475		1,113		317	0	0						715	1,668	834	
Heavy-Duty Refuse Truck Fleet																
CO		16,619				0			16,619				16,619	216,046		
NOx		38,345				0			38,345				38,345	26,841		
PM10		3,858				3,095			3,858				3,858	3,858		
PM2.5		1,529				800			1,529				1,529	1,529		
VOC		2,552				0			2,552				2,552	8,682		

Figure 25. 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
Lifetime Life-Cycle Petroleum Use Costs																
LD Petroleum Use	\$77,794		\$55,567		\$16,202	\$1,761	\$503				\$2,955		\$26,056	\$417		
HD Petroleum Use		\$2,930,239				\$46,172			\$2,270,935		\$128,459			\$16,879		
Lifetime Life-Cycle Greenhouse Gas Emission Costs																
LD GHG Emissions	\$105,494		\$75,353		\$60,160	\$100,108	\$70,856				\$23,388		\$92,813	\$93,871		
HD GHG Emissions		\$3,863,869				\$2,624,733			\$2,994,499		\$1,016,888			\$3,801,288		
Lifetime Vehicle Operation Air Pollutant Emission Costs																
Light-Duty Passenger Car Fleet																
CO	\$0		\$0		\$0	\$0	\$0				\$0		\$0	\$0		
NOx	\$87		\$56		\$16	\$0	\$0				\$163		\$90	\$73		
PM10	\$2,343		\$2,343		\$1,945	\$1,786	\$1,786				\$2,119		\$2,343	\$2,343		
PM2.5	\$7,916		\$7,916		\$5,273	\$4,219	\$4,219				\$7,354		\$7,916	\$7,916		
VOC	\$9,364		\$7,055		\$2,012	\$0	\$0				\$4,543		\$10,616	\$5,301		
Light-Duty Total	\$19,710		\$17,370		\$9,246	\$6,005	\$6,005				\$14,180		\$20,964	\$15,632		
Heavy-Duty Refuse Truck Fleet																
CO		\$0				\$0			\$0		\$0			\$0		
NOx		\$2,859				\$0			\$2,859		\$2,859			\$2,001		
PM10		\$26,315				\$21,075			\$26,315		\$26,315			\$26,315		
PM2.5		\$94,292				\$49,100			\$94,292		\$94,292			\$94,292		
VOC		\$15,918				\$0			\$15,918		\$15,918			\$5,139		
Heavy-Duty Total		\$139,384				\$70,175			\$139,384		\$139,384			\$176,748		
Lifetime Total Petroleum, GHG, and Air Pollutant Costs																
LD Fleet		\$202,997	\$148,289		\$85,608	\$107,874	\$77,364				\$40,522		\$139,833	\$109,920		
HD Fleet		\$6,933,492			\$85,608	\$2,741,081			\$5,404,818		\$1,284,731			\$3,994,915		
Light-Duty Passenger Car Fleet and Infrastructure TCO with Externalities																
Financing	\$102,184		\$117,512		\$173,713	\$153,276	\$298,889				\$114,957		\$132,840	\$137,949		
Depreciation	\$817,574		\$940,210		\$1,390,362	\$1,226,379	\$2,391,403				\$919,771		\$1,062,846	\$1,103,725		
Fuel	\$649,636		\$464,026		\$375,042	\$628,176	\$804,483				\$803,363		\$796,953	\$472,525		
Diesel Exhaust Fluid	\$0		\$0		\$0	\$0	\$0				\$10,688		\$0	\$0		
Maintenance and Repair	\$945,364		\$821,422		\$897,446	\$832,997	\$832,997				\$1,274,465		\$945,364	\$945,364		
Insurance	\$532,774		\$532,774		\$532,774	\$532,774	\$532,774				\$532,774		\$532,774	\$532,774		
License and Registration	\$57,677		\$57,677		\$57,677	\$57,677	\$57,677				\$57,677		\$57,677	\$57,677		
Externalities	\$202,997		\$148,289		\$85,608	\$107,874	\$77,364				\$40,522		\$139,833	\$109,920		
TCO with Externalities	\$3,308,206		\$3,081,909		\$3,512,622	\$3,539,153	\$4,995,587				\$3,754,217		\$3,668,286	\$3,359,933		
Heavy-Duty Refuse Truck Fleet and Infrastructure TCO with Externalities																
Financing		\$1,072,935				\$3,423,173			\$1,277,304		\$1,072,935			\$1,328,396		
Depreciation		\$8,584,525				\$27,389,516			\$10,219,673		\$8,584,525			\$10,628,460		
Fuel		\$22,157,108				\$16,470,132			\$18,241,779		\$34,929,186			\$19,134,852		
Diesel Exhaust Fluid		\$464,704				\$0			\$360,145		\$464,704			\$0		
Maintenance and Repair		\$36,288,112				\$35,509,715			\$35,748,256		\$36,288,112			\$36,476,433		
Insurance		\$2,750,786				\$2,750,786			\$2,750,786		\$2,750,786			\$2,750,786		
License and Registration		\$289,726				\$289,726			\$289,726		\$289,726			\$289,726		
Externalities		\$6,933,492				\$2,741,081			\$5,404,818		\$1,284,731			\$3,994,915		
TCO with Externalities		\$78,541,387				\$88,574,129			\$74,292,486		\$85,664,703			\$74,603,567		

Figure 26. TCO Output Sheet – LDV Cumulative Cash Flow Compared to Gasoline Summary Graph

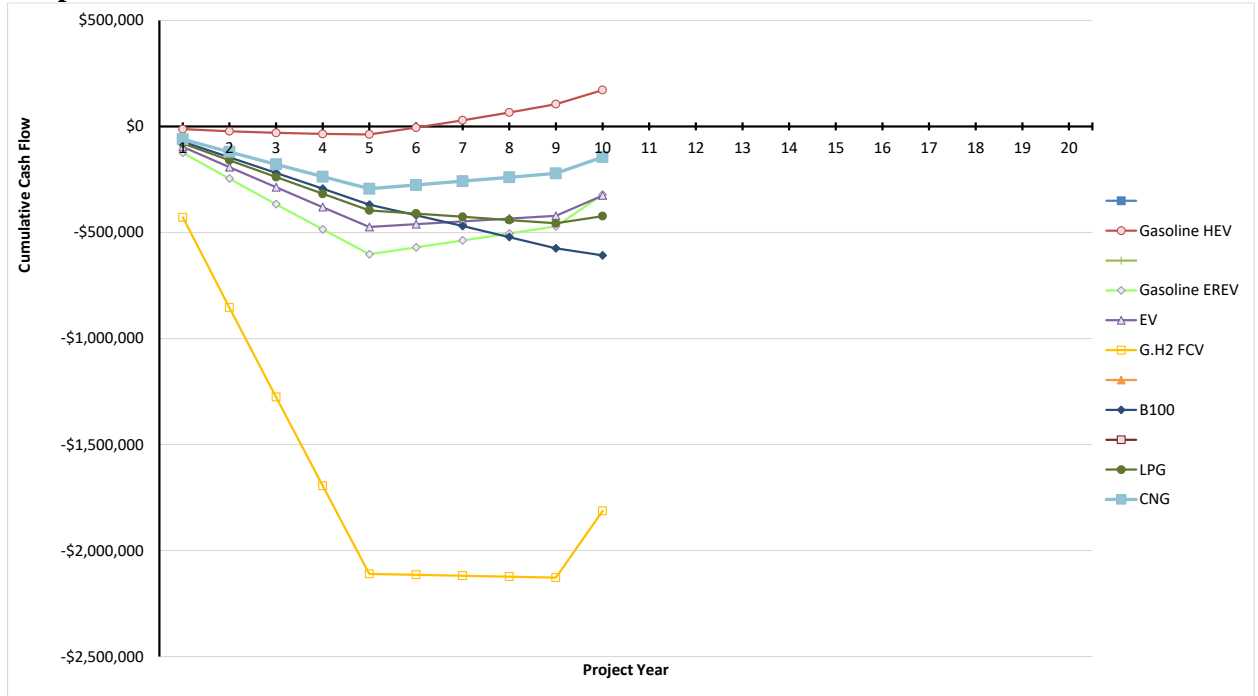


Figure 27. TCO Output Sheet – LDV Cumulative Cash Flow Summary Graph

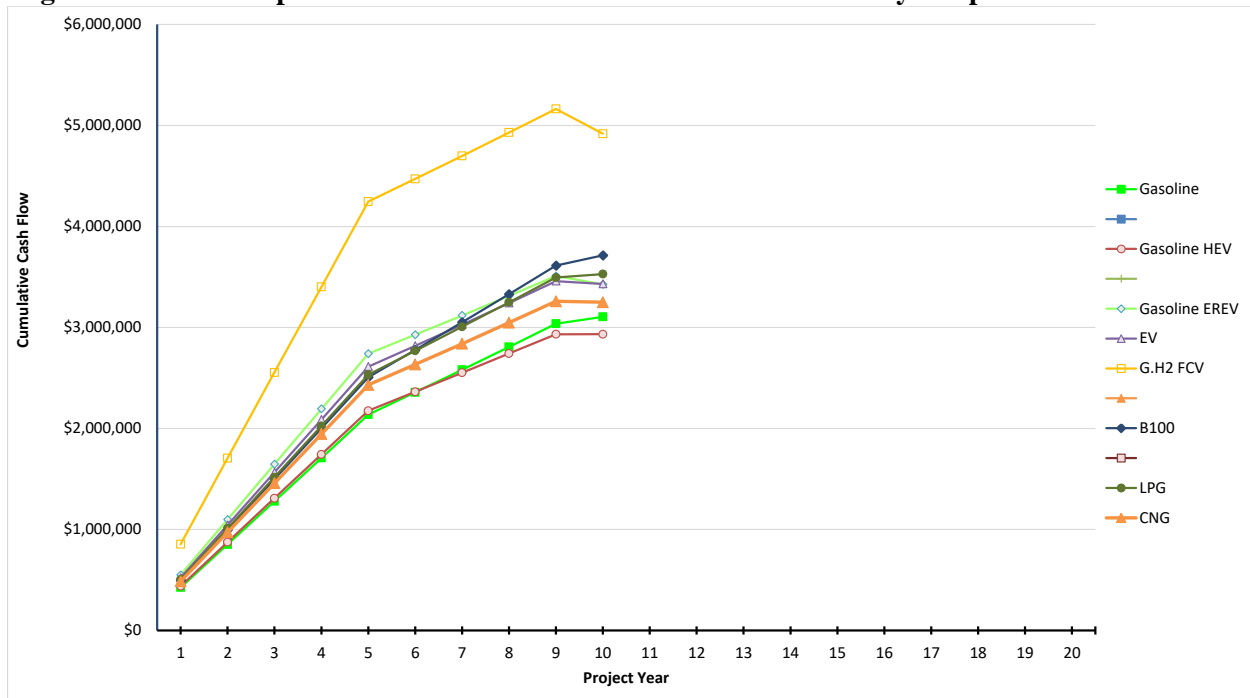


Figure 28. TCO Output Sheet – HDV Total Cost of Ownership Summary Graph

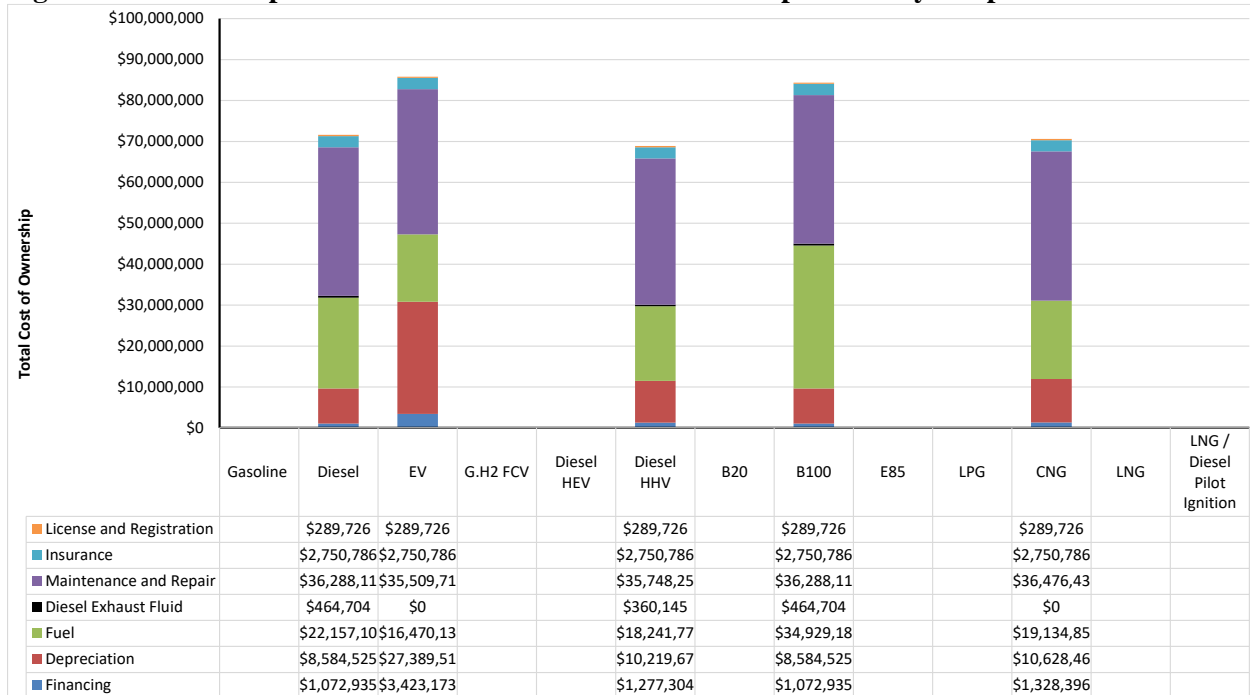


Figure 29. TCO Output Sheet – HDV Total Cost of Ownership w/ Externalities Summary Graph

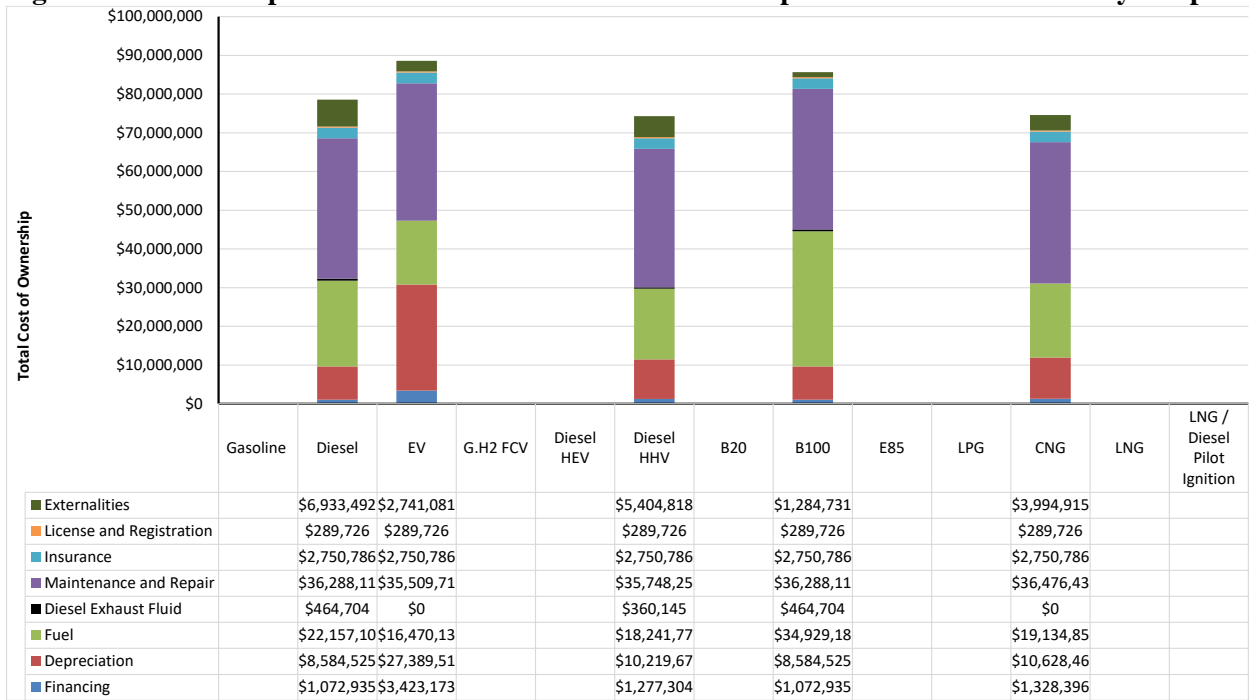


Figure 30. TCO Output Sheet – Lifetime LDV Energy Use and GHGs Summary Graph

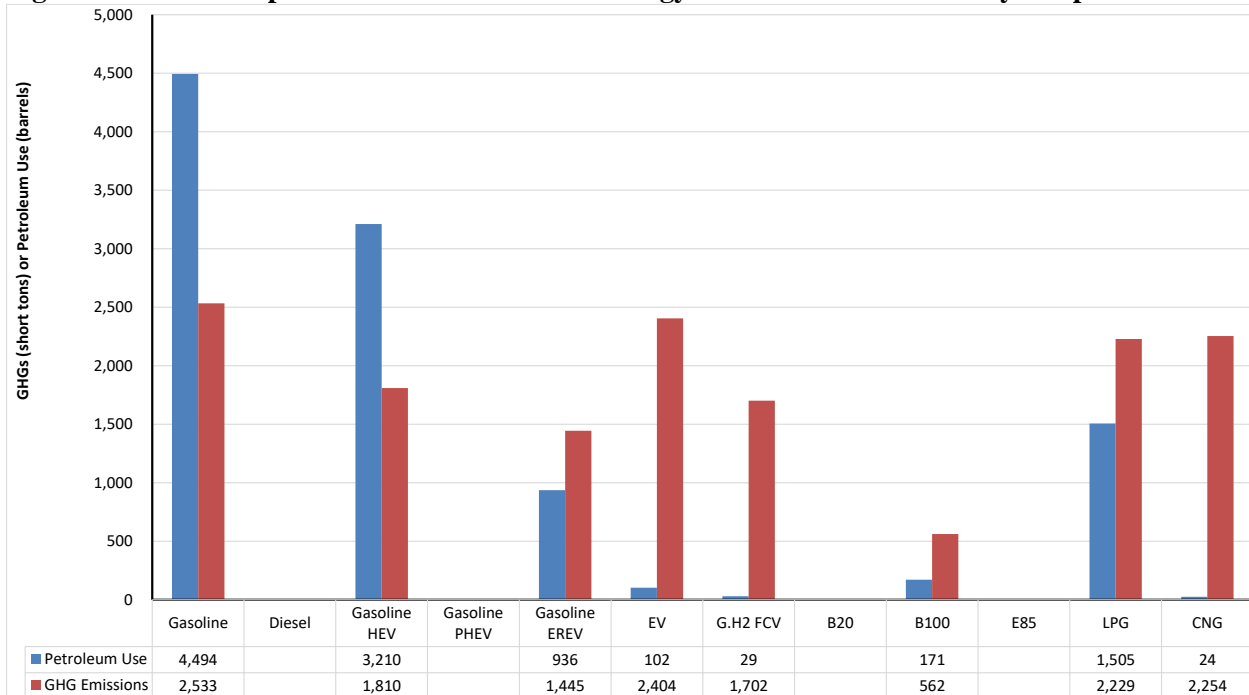


Figure 31. TCO Output Sheet – Lifetime LDV Air Pollutant Emissions Summary Graph

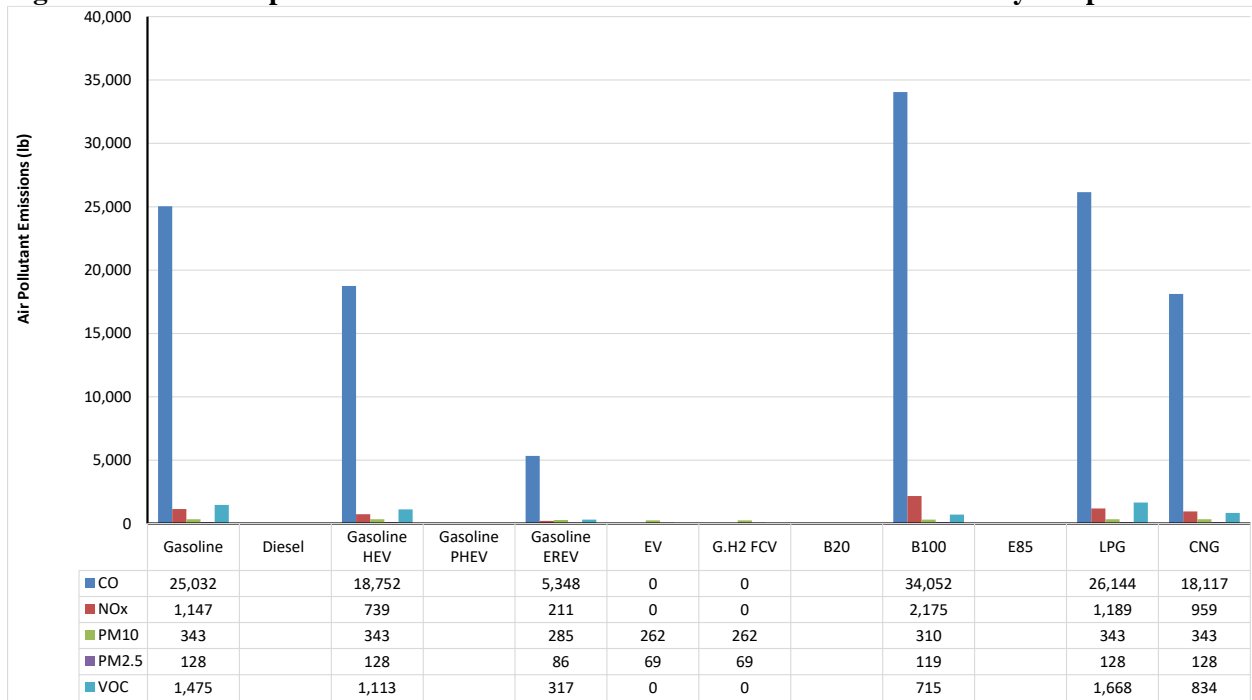


Figure 32. TCO Output Sheet – Lifetime HDV Externality Costs Summary Graph

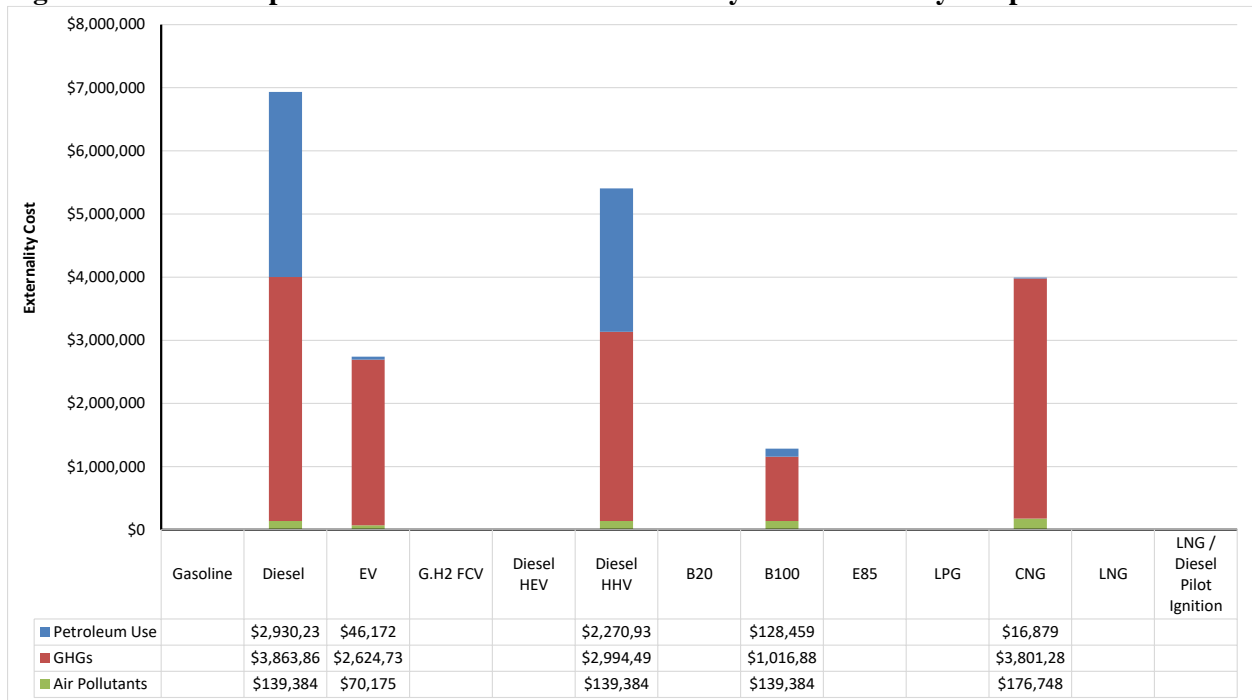


Figure 33. TCO Output Sheet – Lifetime LDV Detailed Externality Costs Summary Graph



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 34) 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 35) 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 2023) below the existing rows.

Figure 34. Footprint-Onroad Sheet - Inputs

State ILLINOIS		Year 2017																		
Vehicle Type	Model Year	Annual Vehicle Mileage	Fuel Use													Remaining Lifetime				
			Gasoline (gal)	Diesel (gal)	Electricity (kWh)	G.H2 (kg)	Diesel HEV (gal)	Diesel HHV (gal)	B20 (gal)	B100 (gal)	RD20 (gal)	RD100 (gal)	E85 (gal)	LPG (gal)	CNG (GGE)	LNG (gal)	Default Lifetime	Calculated Lifetime	Age	Remaining Lifetime
Passenger Car																	0	0	0	0
Light Commercial Truck																	0	0	0	0
Passenger Car																	0	0	0	0
Passenger Car																	0	0	0	0
Passenger Car																	0	0	0	0
Passenger Car																	0	0	0	0
Passenger Car																	0	0	0	0
Passenger Car																	0	0	0	0
Passenger Car																	0	0	0	0
Passenger Car																	0	0	0	0
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
Combination Long-Haul Truck																	0	0	0	0

Figure 35. 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		
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		
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		
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		
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		
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		
Light Commercial Truck	34.8	19.6	262.5	25.0	0.5	1.5	0.4	0.4	9.1	1.9	\$540	\$732	\$0	\$2	\$0	\$7	\$24	\$21	\$51	\$11		
Light Commercial Truck	32.7	18.4	338.5	37.5	0.5	1.4	0.5	0.4	19.0	2.0	\$507	\$688	\$0	\$2	\$0	\$7	\$26	\$20	\$106	\$11		
Light Commercial Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0		
School Bus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0		
School Bus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0		
School Bus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0		
Transit Bus	445.9	244.4	220.5	686.7	45.1	4.3	43.8	1.1	45.7	0.0	\$6,920	\$9,125	\$0	\$45	\$8	\$20	\$2,411	\$60	\$255	\$0		
Transit Bus	388.9	213.2	630.4	1,048.8	58.3	3.8	56.6	1.0	95.4	0.0	\$6,037	\$7,960	\$0	\$69	\$10	\$17	\$3,114	\$53	\$532	\$0		
Transit Bus	414.9	227.4	247.2	639.5	46.4	4.0	45.0	1.0	52.3	0.0	\$6,439	\$8,491	\$0	\$42	\$8	\$18	\$2,477	\$56	\$292	\$0		
Refuse Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0		
Refuse Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0		
Refuse Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0		
Single Unit Short-Haul Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0		
Single Unit Short-Haul Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0		
Single Unit Short-Haul Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0		
Single Unit Long-Haul Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0		
Single Unit Long-Haul Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0		
Single Unit Long-Haul Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0		
Combination Short-Haul Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0		
Combination Short-Haul Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0		
Combination Short-Haul Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0		
Combination Long-Haul Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0		
Combination Long-Haul Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0		
Combination Long-Haul Truck	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0		

2.9 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 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 36) 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 37) 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 36. Footprint-Offroad Sheet - Inputs

State		Year																							
ILLINOIS		2019																							
Equipment Type	Model Year	Annual Usage (hours)	Rated Horsepower (hp)	Fuel Use												Remaining Lifetime									
				Gasoline (gal)	Diesel (gal)	Electricity (kWh)	G.H2 (kg)	B20 (gal)	B100 (gal)	RD20 (gal)	RD100 (gal)	ERS (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	Remaining Lifetime (hr)	Remaining Years	
Aerial Lifts																	361	42	154	1,269	3,000	0	0	0	0
Aerial Lifts																	361	42	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 37. 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 - Well-to-Wheels Petroleum Use	Externality Cost - Well-to-Wheels GHGs					
			CO	NOx	PM10	PM2.5	VOC	VOC (Evap)	SOx	CO	NOx	PM10	PM2.5	VOC	VOC (Evap)			SOx				
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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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 38-42). 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 38. 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 39. 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 40. Footprint Output Sheet – Current Year On-Road Fleet Energy Use and GHGs Summary Graph

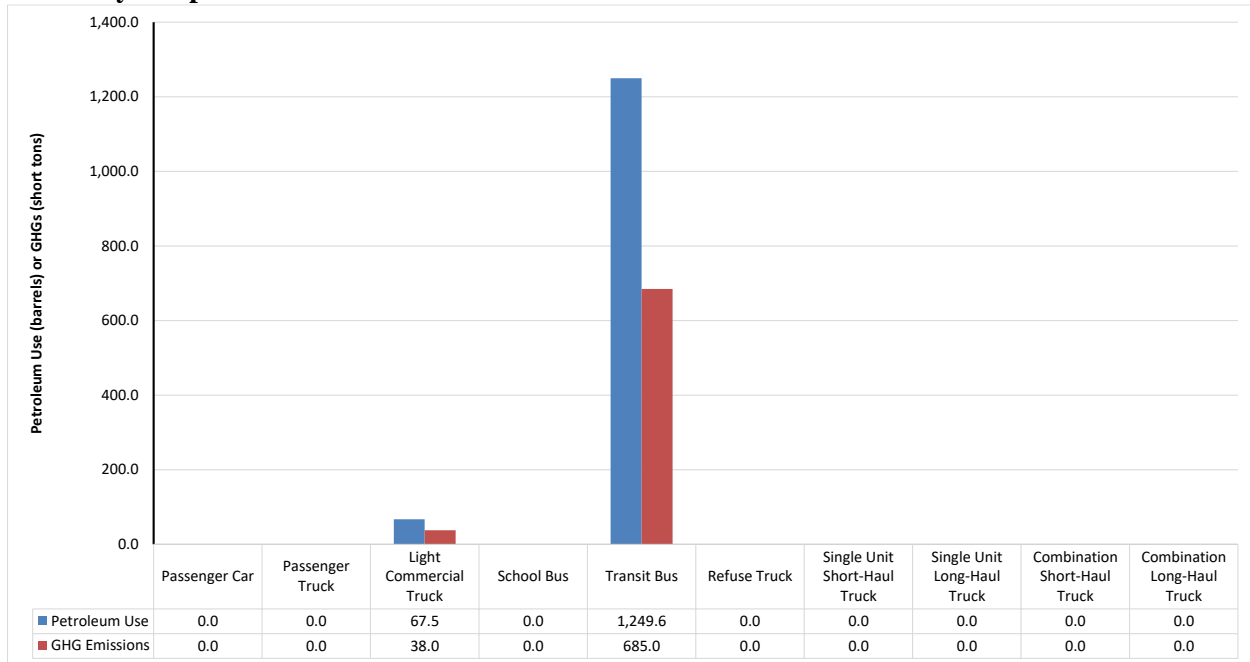


Figure 41. Footprint Output Sheet – Remaining Lifetime On-Road Fleet Air Pollutant Emissions Summary Graph

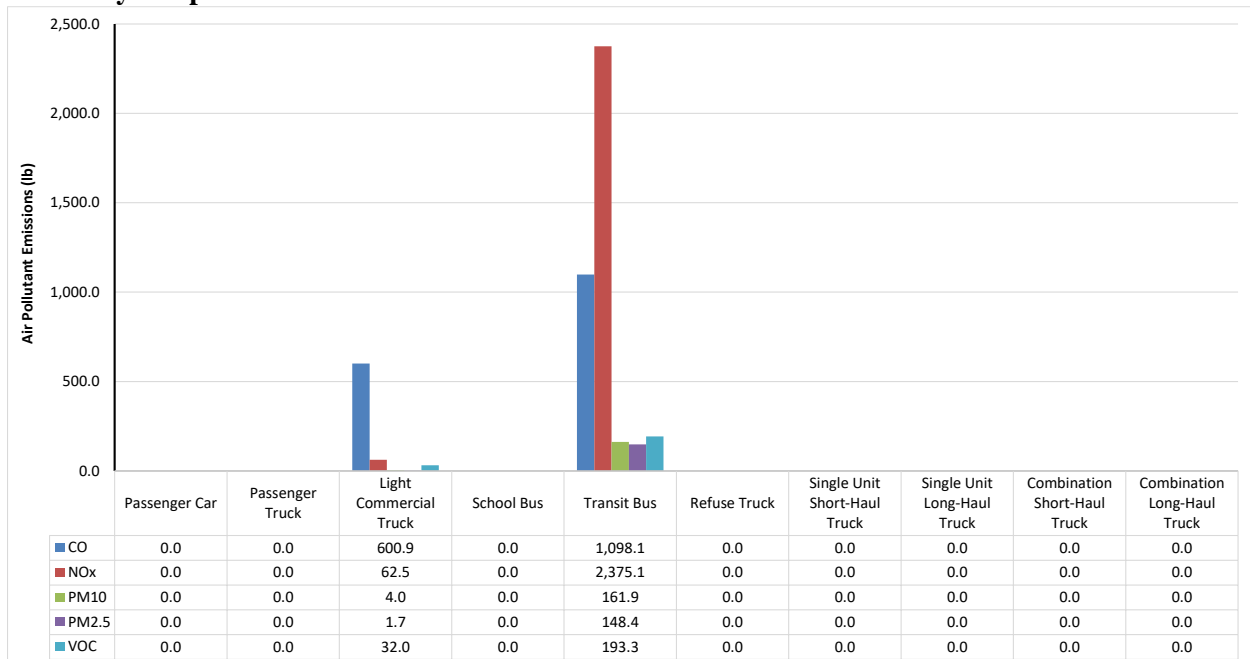
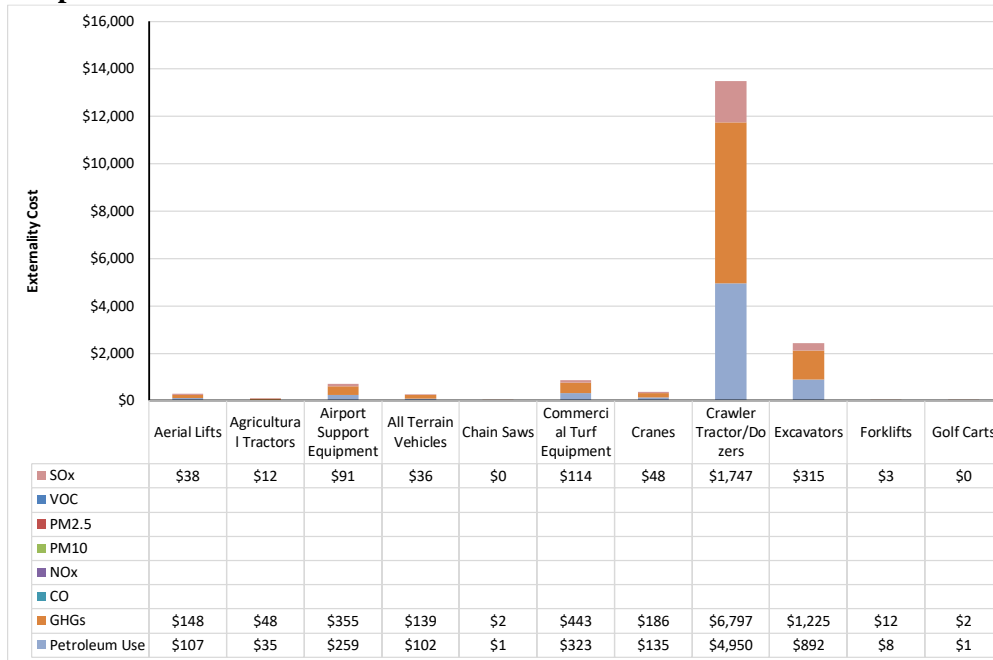


Figure 42. Footprint Output Sheet – Current Year Off-Road Fleet Externality Costs Summary Graph



2.11 CFI Sheet

This sheet contains the Charging and Fueling Infrastructure Emissions Calculator, which estimates the annual petroleum use, GHGs, and air pollutant benefits of utilizing charging and fueling infrastructure. Key assumptions for level 2 and DC fast charging including utilization, average session power, and charge time and for AFV infrastructure including fuel consumption and LDV/HDV utilization from the Inputs sheet are fed into the CFI sheet; CFI inputs are shown in Figure 43. The other tables in this sheet include the petroleum use, GHG emissions, air pollutant emissions, and externality costs.

Figure 43. CFI Sheet – Level 2 Charger, DC Fast Charger, and AFV Infrastructure Inputs

	Parking Lot	Retail & Leisure	Education	Healthcare	Workplace	Multi-Unit Dwelling	Single-Unit Dwelling	Level 2 EVSE	DCFC EVSE	Hydrogen	B20	B100	RD20	RD100	E85	Propane	CNG	LNG	
Charging Location Category	Public	Public	Public	Public	Workplace	Residential	Residential												
Level 2 Charger Inputs																			
Default Weekly Level 2 (L2) Utilization	Moderate																		
Number of L2 Chargers	20	20	20	20	20	20	20												
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)	128.6	94.3	171.4	185.7	128.6	120.0	137.1												
Electricity Dispensed (kWh/year)	46,929	34,414	62,571	67,786	46,929	43,800	50,057												
Annual EV Miles from L2 Charging	130,639	95,802	174,185	188,700	130,639	121,929	139,348												
DC Fast Charger Inputs																			
Default Weekly DC Fast Utilization	Moderate																		
Number of DC Fast Chargers	5	5	5	5	5	5	5												
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)	92.6	92.6	92.6	92.6	92.6	92.6	92.6												
Electricity Dispensed (kWh/year)	33,789	33,789	33,789	33,789	33,789	33,789	33,789												
Annual EV Miles from DC Fast Charging	94,060	94,060	94,060	94,060	94,060	94,060	94,060												
AFV Fueling Infrastructure																			
Default Annual Fuel Consumption	Moderate																		
Number of Stations	20	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Annual Fuel Consumption (fuel)	120,000	140,000	28,000	52,000	52,000	52,000	52,000	217,000	11,000	245,000	163,000								
Annual Fuel Consumption Unit	kWh	kWh	hydrogen	kg	gallon	gallon	gallon	gallon	E85 gallon	LPG gallon	CNG GGE	gallon							
Annual Fuel Consumption (GGE/year)	3,650	4,258	28,000	59,094	55,410	59,404	56,956	159,218	8,329	245,000	108,557								
Light-Duty Vehicle Utilization %	100%	100%	100%	0%	0%	0%	0%	100%	0%	100%	0%								
Heavy-Duty Vehicle Utilization %	0%	0%	0%	100%	100%	100%	100%	0%	100%	100%	100%								
Annual Miles from AFV Station	301,394	351,626	1,293,427	326,736	306,362	328,446	314,914	3,599,552	38,376	1,198,938	531,236								

2.12 CFI Output Sheet

This sheet summarizes the output of the Charging and Fueling Infrastructure Emissions Calculator with tables and graphs for petroleum use, GHG, and air pollutant benefits, as well as fuel dispensed (Figures 44-46). 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 44. CFI 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)	Fuel Dispensed (fuel unit)	Fuel Unit
Level 2 Chargers										
Parking Lot	108.2	36.1	358.7	7.0	0.9	0.8	38.2	0.6	46,929	kWh
Retail & Leisure	79.3	26.5	263.0	5.1	0.7	0.6	28.0	0.4	34,414	kWh
Education	144.2	48.1	478.2	9.3	1.3	1.1	51.0	0.8	62,571	kWh
Healthcare	156.2	52.1	518.1	10.0	1.4	1.2	55.2	0.9	67,786	kWh
Workplace	108.2	36.1	358.7	7.0	0.9	0.8	38.2	0.6	46,929	kWh
Multi-Unit Dwelling	101.0	33.7	334.7	6.5	0.9	0.7	35.7	0.6	43,800	kWh
Single-Unit Dwelling	115.4	38.5	382.6	7.4	1.0	0.9	40.8	0.6	50,057	kWh
L2 Charger Total	812.5	271.1	2,693.9	52.2	7.1	6.0	287.2	4.4	352,486	kWh
DC Fast Chargers										
Parking Lot	77.9	26.0	258.2	5.0	0.7	0.6	27.5	0.4	33,789	kWh
Retail & Leisure	77.9	26.0	258.2	5.0	0.7	0.6	27.5	0.4	33,789	kWh
Education	77.9	26.0	258.2	5.0	0.7	0.6	27.5	0.4	33,789	kWh
Healthcare	77.9	26.0	258.2	5.0	0.7	0.6	27.5	0.4	33,789	kWh
Workplace	77.9	26.0	258.2	5.0	0.7	0.6	27.5	0.4	33,789	kWh
Multi-Unit Dwelling	77.9	26.0	258.2	5.0	0.7	0.6	27.5	0.4	33,789	kWh
Single-Unit Dwelling	77.9	26.0	258.2	5.0	0.7	0.6	27.5	0.4	33,789	kWh
DC Fast Charger Total	545.2	181.9	1,807.6	35.1	4.7	4.0	192.7	3.0	236,520	kWh
AFV Fueling Infrastructure										
Level 2 EVSE	270.1	91.1	829.0	17.5	2.3	2.1	90.6	0.4	120,000	kWh
DCFC EVSE	315.2	106.3	967.1	20.5	2.7	2.4	105.7	0.5	140,000	kWh
Hydrogen	1,180.6	261.1	3,557.5	75.3	10.1	8.9	388.7	6.5	28,000	kg
B20	246.1	92.7	0.0	0.0	0.0	0.0	0.0	1.6	52,000	gal
B100	1,154.0	434.6	0.0	0.0	0.0	0.0	0.0	7.5	52,000	gal
RD20	247.1	89.6	0.0	0.0	0.0	0.0	0.0	1.6	52,000	gal
RD100	1,184.7	429.6	0.0	0.0	0.0	0.0	0.0	7.7	52,000	gal
E85	2,589.0	604.2	0.0	0.0	0.0	0.0	133.3	13.7	217,000	gal
Propane	111.0	-2.8	-1,161.9	168.4	1.4	-0.3	-15.9	0.9	11,000	gal
CNG	4,670.1	202.6	-51,803.7	5,430.0	0.0	0.0	97.2	14.8	245,000	GGE
LNG	2,058.5	56.7	-22,953.6	2,406.0	0.0	0.0	43.1	12.9	163,000	gal
AFV Fueling Infrastructure Total	14,026.3	2,365.7	-70,565.6	8,117.7	16.6	13.0	842.5	68.0		

Figure 45. CFI Output Sheet – Level 2 Charger Petroleum Use and GHGs Benefit

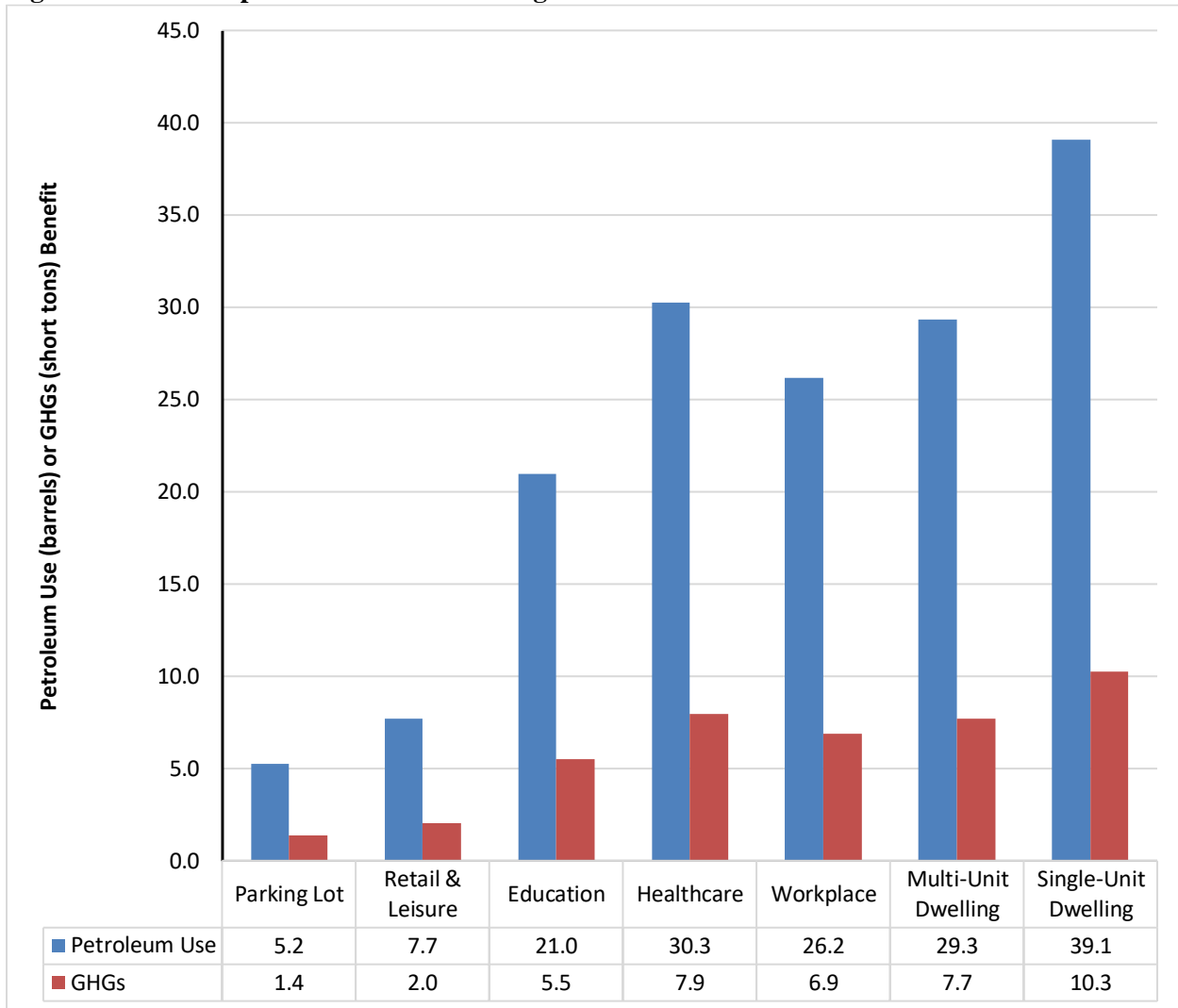


Figure 46. CFI Output Sheet – AFV Fueling Infrastructure Externality Benefit



2.13 EV Rate Sheet

This sheet contains the EV Utility Rate Calculator, which was added to AFLEET 2023. The EV Utility Rate Calculator estimates the utility energy, demand, and fixed costs for charging electric vehicles. The structure of this tool is based on the California Air Resources Board’s Battery Electric Bus and Truck Charging Calculator (Arneja 2019). We utilize National Renewable Energy Laboratory (NREL)’s U.S. Utility Rate Database (USURDB) for commercial and residential rates for select utilities in each state (Zimny-Schmitt 2022). We utilized EIA’s Annual Electric Power Industry Report, Form EIA-861 to examine the total sales of bundled (i.e., both energy and delivery) electricity for each utility as a percentage of the total sales of bundled electricity of all utilities in a given state (EIA 2022). In order to have a manageable number of utilities in the AFLEET spreadsheet, we set a cut off of 5% coverage to include the utility in the tool; however, we chose 1% coverage for Texas to make sure we had adequate coverage of the state. The USURDB does not fully cover all utilities in the EIA database (e.g., TXU Energy Retail), therefore in future iterations of the tool we will look to fill this gap.

The key user inputs (Figure 47) for the EV Utility Rate Calculator are:

- **state** (by default it is linked to Primary Vehicle Location dropdown, but the user can select different states in this section)
- **rate type**
 - **residential:** rate that applies to residential customers

- **commercial:** rate that applies business customers
- **custom:** user defined rate that can be entered on Background Data sheet
- **utility rate name (utility “common name” + rate name + rate structure + demand limit)**
 - **rate structure**
 - **flat:** rate structure where the energy and demand charges do not change over time of day (e.g., they are always off-peak).
 - **TOU (time-of-use):** rate structure where the energy and demand charges change over time of day. AFLEET uses three TOU periods, as this is the typical structure for utilities. In some cases, all three are used in a rate, while in others only off-peak and on-peak are used.
 - **off-peak:** period when electricity demand is lowest during the day; lowest cost per kWh/kW
 - **mid-peak:** period when electricity demand is neither at its lowest or highest point during the day; an intermediary amount is paid per kWh/kW
 - **on-peak:** period when electricity demand is highest during the day; lowest cost per kWh/kW
 - **EV:** rate structure designed by utility specifically for EV charging
 - **demand limit:** minimum and maximum kW for which the rate is applicable (e.g. if your max demand is 60 kW and the rate is for 50 kW or less, you would not be eligible to use that rate)
- **charging strategy**
 - **managed:** To reduce demand charges, users selecting “managed charging” will have the charger power throttled down to the minimum power required to charge the vehicle during the charging period
 - **unmanaged:** charger will operate at full power
- **charging period: start time** (charging starts at this time)
- **charging period: end time** (If using managed strategy, charging will end at this time. When using unmanaged charging, charging can finish before this time based on charger rating and amount of energy to be dispensed. Make sure charging period is long enough or charger rating is high enough to meet the needed energy to be dispensed. EV Rate Calculator gives a warning in the Helpful Comments table if “charger rating is insufficient for fully charging your fleet within the charging period”).
- **charger rating (kW)**
- **charging days per week**
- **number of EVs**
- **daily EV mileage**
- **EV electricity use (kwh/mi)**

2.14 Charger TCO Sheet

This sheet contains the EV Charger TCO Calculator, which estimates charger capital costs, charger operating costs, and electricity costs to calculate the lifetime total cost of ownership of an EV charger. The structure of the TCO calculations is to look at the capital, operation, and electricity costs on an annual basis for every year of the charger's lifetime ownership of a new vehicle and infrastructure purchase (Figure 50, several project year columns are not shown for clarity's sake).

The key inputs for this calculator are on the Inputs sheet, but the user can define rates for each charger types (e.g., residential level 1 vs. residential level 2) on the Charger TCO sheet using the "EV Utility Multi-Rate Calculator" (Figure 51). The user can select three rates for the 13 charger/use type combinations.

Figure 50 Charger TCO Sheet – Calculations

EV Charger TCO Calculator Project Year 0 1 2 3 4 5 6 7 8 9 10
Residential Level 1 - Light-Duty Vehicle

Use Type Light-Duty Vehicle
 Charger Type Residential Level 1

Charging Assumptions (Charger Lifetime)

Rated power	kW	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Number of Chargers	chargers/site	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Max grid power demand at site	kW	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Charger efficiency	%	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Utilization	sessions/yr	312.0	312.0	312.0	312.0	312.0	312.0	312.0	312.0	312.0	312.0
Charge Time	hr/session	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
Average session power	kW	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Grid Power Delivered to EVSE	kW	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
EVSE energy dispensed to vehicle	kWh/session	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3
Grid energy dispensed to EVSE	kWh/session	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3
EVSE energy dispensed to vehicle	kWh/yr	3,533.2	3,533.2	3,533.2	3,533.2	3,533.2	3,533.2	3,533.2	3,533.2	3,533.2	3,533.2
Grid energy dispensed to EVSE	kWh/yr	4,156.6	4,156.6	4,156.6	4,156.6	4,156.6	4,156.6	4,156.6	4,156.6	4,156.6	4,156.6

Charging Assumptions (Infrastructure Lifetime) - ONLY USED FOR COST PER KWH CALCULATION

Rated power	kW	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Number of Chargers	chargers/site	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Max grid power demand at site	kW	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Charger efficiency	%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%
Utilization	sessions/yr	312.0	312.0	312.0	312.0	312.0	312.0	312.0	312.0	312.0	312.0
Charge Time	hr/session	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
Average session power	kW	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Grid Power Delivered to EVSE	kW	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
EVSE energy dispensed to vehicle	kWh/session	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3
Grid energy dispensed to EVSE	kWh/session	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3
EVSE energy dispensed to vehicle	kWh/yr	3,533.2	3,533.2	3,533.2	3,533.2	3,533.2	3,533.2	3,533.2	3,533.2	3,533.2	3,533.2
Grid energy dispensed to EVSE	kWh/yr	4,156.6	4,156.6	4,156.6	4,156.6	4,156.6	4,156.6	4,156.6	4,156.6	4,156.6	4,156.6

Charger Capital Cost (\$)

Charger Incentive	\$	\$ -									
Infrastructure incentive	\$	\$ -									
Charger cost	\$	\$ 380									
Infrastructure cost	\$	\$ -									
Total Charger Capital Cost	\$	\$ 380									

Charger Operation Cost (\$/yr)

Maintenance cost	\$/yr	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Communications cost	\$/yr	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Warranty cost	\$/yr	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Host site access cost	\$/yr	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Total Charger Operation Cost	\$/yr	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -

Electricity Cost (\$/yr)

Energy charge (Rate 1)	\$/yr	\$ 267	\$ 267	\$ 267	\$ 267	\$ 267	\$ 267	\$ 267	\$ 267	\$ 267	\$ 267
Energy charge (Rate 2)	\$/yr	\$ 252	\$ 252	\$ 252	\$ 252	\$ 252	\$ 252	\$ 252	\$ 252	\$ 252	\$ 252
Energy charge (Rate 3)	\$/yr	\$ 390	\$ 390	\$ 390	\$ 390	\$ 390	\$ 390	\$ 390	\$ 390	\$ 390	\$ 390
Demand charge (Rate 1)	\$/yr	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Demand charge (Rate 2)	\$/yr	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Demand charge (Rate 3)	\$/yr	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Fixed charge (Rate 1)	\$/yr	\$ 183	\$ 183	\$ 183	\$ 183	\$ 183	\$ 183	\$ 183	\$ 183	\$ 183	\$ 183
Fixed charge (Rate 2)	\$/yr	\$ 18	\$ 18	\$ 18	\$ 18	\$ 18	\$ 18	\$ 18	\$ 18	\$ 18	\$ 18
Fixed charge (Rate 3)	\$/yr	\$ 183	\$ 183	\$ 183	\$ 183	\$ 183	\$ 183	\$ 183	\$ 183	\$ 183	\$ 183
Total Electricity cost (Rate 1)	\$/yr	\$ 450	\$ 450	\$ 450	\$ 450	\$ 450	\$ 450	\$ 450	\$ 450	\$ 450	\$ 450
Total Electricity cost (Rate 2)	\$/yr	\$ 270	\$ 270	\$ 270	\$ 270	\$ 270	\$ 270	\$ 270	\$ 270	\$ 270	\$ 270
Total Electricity cost (Rate 3)	\$/yr	\$ 573	\$ 573	\$ 573	\$ 573	\$ 573	\$ 573	\$ 573	\$ 573	\$ 573	\$ 573

Cash Flow (\$/yr)

Annual Net Cash Flow (Rate 1)	\$/yr	\$ (380)	\$ (450)	\$ (450)	\$ (450)	\$ (450)	\$ (450)	\$ (450)	\$ (450)	\$ (450)	\$ (450)
Annual Net Cash Flow (Rate 2)	\$/yr	\$ (380)	\$ (270)	\$ (270)	\$ (270)	\$ (270)	\$ (270)	\$ (270)	\$ (270)	\$ (270)	\$ (270)
Annual Net Cash Flow (Rate 3)	\$/yr	\$ (380)	\$ (573)	\$ (573)	\$ (573)	\$ (573)	\$ (573)	\$ (573)	\$ (573)	\$ (573)	\$ (573)
Annual Discounted Cash Flow (Rate 1)	\$/yr	\$ (380)	\$ (441)	\$ (433)	\$ (425)	\$ (417)	\$ (409)	\$ (402)	\$ (394)	\$ (387)	\$ (380)
Annual Discounted Cash Flow (Rate 2)	\$/yr	\$ (380)	\$ (265)	\$ (260)	\$ (256)	\$ (251)	\$ (246)	\$ (242)	\$ (237)	\$ (233)	\$ (228)
Annual Discounted Cash Flow (Rate 3)	\$/yr	\$ (380)	\$ (562)	\$ (552)	\$ (542)	\$ (532)	\$ (522)	\$ (512)	\$ (503)	\$ (493)	\$ (484)

Net Present Value (NPV) (\$)

NPV (Rate 1)	\$	\$ (6,206)
NPV (Rate 2)	\$	\$ (3,881)
NPV (Rate 3)	\$	\$ (7,805)

Cost per kWh

Levelized Cost (Rate 1)	\$/kWh	\$ 0.13
Levelized Cost (Rate 2)	\$/kWh	\$ 0.08
Levelized Cost (Rate 3)	\$/kWh	\$ 0.17

Figure 51. Charger TCO Sheet – EV Utility Multi-Rate Calculator

Charger Type	Use Type	Rate Number	State	Rate Type	Rate Structure	Utility Rate Name	Charging Strategy	Charging Period: Start Time	Charging Period: End Time
Residential Level 1	Light-Duty Vehicle	1	ALABAMA	Residential	Flat	Alabama Power: Family Dwelling Service (Demand Option) (Flat, >0 kW)	Unmanaged	8:00 PM	7:00 AM
Residential Level 1	Light-Duty Vehicle	2	ALABAMA	Residential	TOU	Alabama Power: Rate PAE - Option B - Three Phase (TOU, >0 kW)	Unmanaged	8:00 PM	7:00 AM
Residential Level 1	Light-Duty Vehicle	3	ALABAMA	Residential	EV	Alabama Power: Plug-In Electric Vehicle (EV, >0 kW)	Unmanaged	8:00 PM	7:00 AM
Residential Level 2	Light-Duty Vehicle	1	ALABAMA	Residential	Flat	Alabama Power: Family Dwelling Service (Demand Option) (Flat, >0 kW)	Unmanaged	8:00 PM	7:00 AM
Residential Level 2	Light-Duty Vehicle	2	ALABAMA	Residential	TOU	Alabama Power: Rate PAE - Option B - Three Phase (TOU, >0 kW)	Unmanaged	8:00 PM	7:00 AM
Residential Level 2	Light-Duty Vehicle	3	ALABAMA	Residential	EV	Alabama Power: Plug-In Electric Vehicle (EV, >0 kW)	Unmanaged	8:00 PM	7:00 AM
Publicly Accessible Level 2	Light-Duty Vehicle	1	ALABAMA	Commercial	Flat	Alabama Power: AGRICULTURAL SERVICE - LARGE (Flat, >0 kW)	Unmanaged	10:00 AM	10:00 PM
Publicly Accessible Level 2	Light-Duty Vehicle	2	ALABAMA	Commercial	TOU	Alabama Power: BTA - BUSINESS TIME ADVANTAGE (OPTIONAL) - Primary (TOU, >0 kW)	Unmanaged	10:00 AM	10:00 PM
Publicly Accessible Level 2	Light-Duty Vehicle	3	ALABAMA	Commercial	EV	Alabama Power: Business Electric Vehicle- Time of Use (EV, >0 kW)	Unmanaged	10:00 AM	10:00 PM
Publicly Accessible DCFC: 50-100 kW	All Vehicles	1	ALABAMA	Commercial	Flat	Alabama Power: AGRICULTURAL SERVICE - LARGE (Flat, >0 kW)	Unmanaged	10:00 AM	10:00 PM
Publicly Accessible DCFC: 50-100 kW	All Vehicles	2	ALABAMA	Commercial	TOU	Alabama Power: BTA - BUSINESS TIME ADVANTAGE (OPTIONAL) - Primary (TOU, >0 kW)	Unmanaged	10:00 AM	10:00 PM
Publicly Accessible DCFC: 50-100 kW	All Vehicles	3	ALABAMA	Commercial	EV	Alabama Power: Business Electric Vehicle- Time of Use (EV, >0 kW)	Unmanaged	10:00 AM	10:00 PM
Publicly Accessible DCFC: 100-300 kW	All Vehicles	1	ALABAMA	Commercial	Flat	Alabama Power: AGRICULTURAL SERVICE - LARGE (Flat, >0 kW)	Unmanaged	10:00 AM	10:00 PM
Publicly Accessible DCFC: 100-300 kW	All Vehicles	2	ALABAMA	Commercial	TOU	Alabama Power: BTA - BUSINESS TIME ADVANTAGE (OPTIONAL) - Primary (TOU, >0 kW)	Unmanaged	10:00 AM	10:00 PM
Publicly Accessible DCFC: 100-300 kW	All Vehicles	3	ALABAMA	Commercial	EV	Alabama Power: Business Electric Vehicle- Time of Use (EV, >0 kW)	Unmanaged	10:00 AM	10:00 PM
Publicly Accessible DCFC: 300+ kW	All Vehicles	1	ALABAMA	Commercial	Flat	Alabama Power: AGRICULTURAL SERVICE - LARGE (Flat, >0 kW)	Unmanaged	10:00 AM	10:00 PM
Publicly Accessible DCFC: 300+ kW	All Vehicles	2	ALABAMA	Commercial	TOU	Alabama Power: BTA - BUSINESS TIME ADVANTAGE (OPTIONAL) - Primary (TOU, >0 kW)	Unmanaged	10:00 AM	10:00 PM
Publicly Accessible DCFC: 300+ kW	All Vehicles	3	ALABAMA	Commercial	EV	Alabama Power: Business Electric Vehicle- Time of Use (EV, >0 kW)	Unmanaged	10:00 AM	10:00 PM
Fleet DCFC: 50-100 kW	School Bus	1	ALABAMA	Commercial	Flat	Alabama Power: AGRICULTURAL SERVICE - LARGE (Flat, >0 kW)	Unmanaged	6:00 PM	5:00 AM
Fleet DCFC: 50-100 kW	School Bus	2	ALABAMA	Commercial	TOU	Alabama Power: BTA - BUSINESS TIME ADVANTAGE (OPTIONAL) - Primary (TOU, >0 kW)	Unmanaged	6:00 PM	5:00 AM
Fleet DCFC: 50-100 kW	School Bus	3	ALABAMA	Commercial	EV	Alabama Power: Business Electric Vehicle- Time of Use (EV, >0 kW)	Unmanaged	6:00 PM	5:00 AM
Fleet DCFC: 50-100 kW	Transit Bus	1	ALABAMA	Commercial	Flat	Alabama Power: AGRICULTURAL SERVICE - LARGE (Flat, >0 kW)	Unmanaged	6:00 PM	5:00 AM
Fleet DCFC: 50-100 kW	Transit Bus	2	ALABAMA	Commercial	TOU	Alabama Power: BTA - BUSINESS TIME ADVANTAGE (OPTIONAL) - Primary (TOU, >0 kW)	Unmanaged	6:00 PM	5:00 AM
Fleet DCFC: 50-100 kW	Transit Bus	3	ALABAMA	Commercial	EV	Alabama Power: Business Electric Vehicle- Time of Use (EV, >0 kW)	Unmanaged	6:00 PM	5:00 AM
Fleet DCFC: 50-100 kW	Refuse Truck	1	ALABAMA	Commercial	Flat	Alabama Power: AGRICULTURAL SERVICE - LARGE (Flat, >0 kW)	Unmanaged	6:00 PM	5:00 AM
Fleet DCFC: 50-100 kW	Refuse Truck	2	ALABAMA	Commercial	TOU	Alabama Power: BTA - BUSINESS TIME ADVANTAGE (OPTIONAL) - Primary (TOU, >0 kW)	Unmanaged	6:00 PM	5:00 AM
Fleet DCFC: 50-100 kW	Refuse Truck	3	ALABAMA	Commercial	EV	Alabama Power: Business Electric Vehicle- Time of Use (EV, >0 kW)	Unmanaged	6:00 PM	5:00 AM
Fleet DCFC: 50-100 kW	Single Unit Short-Haul Truck	1	ALABAMA	Commercial	Flat	Alabama Power: AGRICULTURAL SERVICE - LARGE (Flat, >0 kW)	Unmanaged	6:00 PM	5:00 AM
Fleet DCFC: 50-100 kW	Single Unit Short-Haul Truck	2	ALABAMA	Commercial	TOU	Alabama Power: BTA - BUSINESS TIME ADVANTAGE (OPTIONAL) - Primary (TOU, >0 kW)	Unmanaged	6:00 PM	5:00 AM
Fleet DCFC: 50-100 kW	Single Unit Short-Haul Truck	3	ALABAMA	Commercial	EV	Alabama Power: Business Electric Vehicle- Time of Use (EV, >0 kW)	Unmanaged	6:00 PM	5:00 AM
Fleet DCFC: 50-100 kW	Single Unit Long-Haul Truck	1	ALABAMA	Commercial	Flat	Alabama Power: AGRICULTURAL SERVICE - LARGE (Flat, >0 kW)	Unmanaged	6:00 PM	5:00 AM
Fleet DCFC: 50-100 kW	Single Unit Long-Haul Truck	2	ALABAMA	Commercial	TOU	Alabama Power: BTA - BUSINESS TIME ADVANTAGE (OPTIONAL) - Primary (TOU, >0 kW)	Unmanaged	6:00 PM	5:00 AM
Fleet DCFC: 50-100 kW	Single Unit Long-Haul Truck	3	ALABAMA	Commercial	EV	Alabama Power: Business Electric Vehicle- Time of Use (EV, >0 kW)	Unmanaged	6:00 PM	5:00 AM
Fleet DCFC: 50-100 kW	Combination Short-Haul Truck	1	ALABAMA	Commercial	Flat	Alabama Power: AGRICULTURAL SERVICE - LARGE (Flat, >0 kW)	Unmanaged	6:00 PM	5:00 AM
Fleet DCFC: 50-100 kW	Combination Short-Haul Truck	2	ALABAMA	Commercial	TOU	Alabama Power: BTA - BUSINESS TIME ADVANTAGE (OPTIONAL) - Primary (TOU, >0 kW)	Unmanaged	6:00 PM	5:00 AM
Fleet DCFC: 50-100 kW	Combination Short-Haul Truck	3	ALABAMA	Commercial	EV	Alabama Power: Business Electric Vehicle- Time of Use (EV, >0 kW)	Unmanaged	6:00 PM	5:00 AM
Fleet DCFC: 50-100 kW	Combination Long-Haul Truck	1	ALABAMA	Commercial	Flat	Alabama Power: AGRICULTURAL SERVICE - LARGE (Flat, >0 kW)	Unmanaged	6:00 PM	5:00 AM
Fleet DCFC: 50-100 kW	Combination Long-Haul Truck	2	ALABAMA	Commercial	TOU	Alabama Power: BTA - BUSINESS TIME ADVANTAGE (OPTIONAL) - Primary (TOU, >0 kW)	Unmanaged	6:00 PM	5:00 AM
Fleet DCFC: 50-100 kW	Combination Long-Haul Truck	3	ALABAMA	Commercial	EV	Alabama Power: Business Electric Vehicle- Time of Use (EV, >0 kW)	Unmanaged	6:00 PM	5:00 AM

2.15 Charger TCO Output Sheet

This sheet summarizes the output of EV Charger TCO Calculator with tables and graphs of the TCO of each charger and rate type combination. The first table displays the levelized cost of charging (\$/kWh), which is calculated as the sum of lifetime charger capital, charger operating, and electricity costs divided by the lifetime electricity dispensed to vehicles (Figure 52). Figure 53 shows the lifetime EV charger costs by type for the three rate cases. This sheet also has two types of charts with these costs: detailed and simplified breakdowns (Figure 54-55).

Figure 52. Charger TCO Output Sheet – Levelized Cost of Charging (\$/kWh)

Charger Type	Use Type	Rate 1	Rate 2	Rate 3
Residential Level 1	Light-Duty Vehicle	\$0.13	\$0.08	\$0.17
Residential Level 2	Light-Duty Vehicle	\$0.14	\$0.16	\$0.19
Publicly Accessible Level 2	Light-Duty Vehicle	\$0.86	\$2.10	\$1.21
Publicly Accessible DCFC: 50-100 kW	All Vehicles	\$0.99	\$1.67	\$1.12
Publicly Accessible DCFC: 100-300 kW	All Vehicles	\$1.27	\$2.15	\$1.35
Publicly Accessible DCFC: 300+ kW	All Vehicles	\$1.94	\$3.83	\$2.02
Fleet DCFC: 50-100 kW	School Bus	\$0.46	\$0.61	\$0.53
Fleet DCFC: 50-100 kW	Transit Bus	\$0.21	\$0.22	\$0.23
Fleet DCFC: 50-100 kW	Refuse Truck	\$0.29	\$0.35	\$0.33
Fleet DCFC: 50-100 kW	Single Unit Short-Haul Truck	\$0.75	\$1.04	\$0.85
Fleet DCFC: 50-100 kW	Single Unit Long-Haul Truck	\$0.43	\$0.56	\$0.49
Fleet DCFC: 50-100 kW	Combination Short-Haul Truck	\$0.18	\$0.18	\$0.19
Fleet DCFC: 50-100 kW	Combination Long-Haul Truck	\$0.07	\$0.07	\$0.08

Figure 53. Charger TCO Output Sheet – Lifetime EV Charger Costs Table

	Residential Level 1 - Light-Duty Vehicle	Residential Level 2 - Light-Duty Vehicle	Publicly Accessible Level 2 - Light-Duty Vehicle	Publicly Accessible DCFC: 50-100 kW - All Vehicles	Publicly Accessible DCFC: 100-300 kW - All Vehicles	Publicly Accessible DCFC: 300+ kW - All Vehicles	Fleet DCFC: 50-100 kW - School Bus	Fleet DCFC: 50-100 kW - Transit Bus	Fleet DCFC: 50-100 kW - Refuse Truck	Fleet DCFC: 50-100 kW - Single Unit Short-Haul Truck	Fleet DCFC: 50-100 kW - Single Unit Long-Haul Truck	Fleet DCFC: 50-100 kW - Combination Short-Haul Truck	Fleet DCFC: 50-100 kW - Combination Long-Haul Truck
Rate 1													
Charger	\$380	\$689	\$4,900	\$27,900	\$87,800	\$139,000	\$27,900	\$27,900	\$27,900	\$27,900	\$27,900	\$27,900	\$27,900
Infrastructure	\$0	\$480	\$7,000	\$62,700	\$75,500	\$138,200	\$62,700	\$62,700	\$62,700	\$62,700	\$62,700	\$62,700	\$62,700
Maintenance	\$0	\$0	\$452	\$2,576	\$8,105	\$12,832	\$2,576	\$2,576	\$2,576	\$2,576	\$2,576	\$2,576	\$2,576
Communications	\$0	\$0	\$4,708	\$4,708	\$4,708	\$4,708	\$4,708	\$4,708	\$4,708	\$4,708	\$4,708	\$4,708	\$4,708
Warranty	\$0	\$0	\$6,333	\$36,059	\$113,475	\$179,647	\$36,059	\$36,059	\$36,059	\$36,059	\$36,059	\$36,059	\$36,059
Host site access	\$0	\$0	\$9,232	\$9,232	\$9,232	\$9,232	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Electricity energy charge	\$4,000	\$4,000	\$5,153	\$15,459	\$26,796	\$26,796	\$35,715	\$130,136	\$70,750	\$19,736	\$39,128	\$182,173	\$184,292
Electricity demand charge	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Electricity fixed charge	\$2,745	\$2,745	\$3,692	\$3,692	\$3,692	\$3,692	\$3,692	\$3,692	\$3,692	\$3,692	\$3,692	\$3,692	\$3,692
Total Cost of Ownership	\$7,125	\$7,914	\$41,470	\$162,325	\$329,307	\$514,106	\$173,349	\$267,770	\$208,384	\$157,370	\$176,762	\$319,807	\$321,526
Rate 2													
Charger	\$380	\$689	\$4,900	\$27,900	\$87,800	\$139,000	\$27,900	\$27,900	\$27,900	\$27,900	\$27,900	\$27,900	\$27,900
Infrastructure	\$0	\$480	\$7,000	\$62,700	\$75,500	\$138,200	\$62,700	\$62,700	\$62,700	\$62,700	\$62,700	\$62,700	\$62,700
Maintenance	\$0	\$0	\$452	\$2,576	\$8,105	\$12,832	\$2,576	\$2,576	\$2,576	\$2,576	\$2,576	\$2,576	\$2,576
Communications	\$0	\$0	\$4,708	\$4,708	\$4,708	\$4,708	\$4,708	\$4,708	\$4,708	\$4,708	\$4,708	\$4,708	\$4,708
Warranty	\$0	\$0	\$6,333	\$36,059	\$113,475	\$179,647	\$36,059	\$36,059	\$36,059	\$36,059	\$36,059	\$36,059	\$36,059
Host site access	\$0	\$0	\$9,232	\$9,232	\$9,232	\$9,232	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Electricity energy charge	\$3,784	\$7,370	\$3,461	\$10,383	\$17,997	\$17,997	\$23,988	\$87,406	\$47,520	\$13,256	\$26,281	\$122,357	\$123,780
Electricity demand charge	\$0	\$0	\$19,535	\$58,140	\$174,420	\$406,980	\$19,535	\$19,535	\$19,535	\$19,535	\$19,535	\$19,535	\$19,535
Electricity fixed charge	\$270	\$270	\$40,835	\$40,835	\$40,835	\$40,835	\$40,835	\$40,835	\$40,835	\$40,835	\$40,835	\$40,835	\$40,835
Total Cost of Ownership	\$4,434	\$8,809	\$96,456	\$252,532	\$532,072	\$949,430	\$218,300	\$281,718	\$241,832	\$207,568	\$220,593	\$316,669	\$318,092
Rate 3													
Charger	\$380	\$689	\$4,900	\$27,900	\$87,800	\$139,000	\$27,900	\$27,900	\$27,900	\$27,900	\$27,900	\$27,900	\$27,900
Infrastructure	\$0	\$480	\$7,000	\$62,700	\$75,500	\$138,200	\$62,700	\$62,700	\$62,700	\$62,700	\$62,700	\$62,700	\$62,700
Maintenance	\$0	\$0	\$452	\$2,576	\$8,105	\$12,832	\$2,576	\$2,576	\$2,576	\$2,576	\$2,576	\$2,576	\$2,576
Communications	\$0	\$0	\$4,708	\$4,708	\$4,708	\$4,708	\$4,708	\$4,708	\$4,708	\$4,708	\$4,708	\$4,708	\$4,708
Warranty	\$0	\$0	\$6,333	\$36,059	\$113,475	\$179,647	\$36,059	\$36,059	\$36,059	\$36,059	\$36,059	\$36,059	\$36,059
Host site access	\$0	\$0	\$9,232	\$9,232	\$9,232	\$9,232	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Electricity energy charge	\$5,851	\$6,178	\$5,902	\$17,706	\$30,691	\$30,691	\$40,907	\$132,580	\$78,801	\$22,605	\$44,816	\$179,705	\$178,945
Electricity demand charge	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Electricity fixed charge	\$2,745	\$2,745	\$18,335	\$18,335	\$18,335	\$18,335	\$18,335	\$18,335	\$18,335	\$18,335	\$18,335	\$18,335	\$18,335
Total Cost of Ownership	\$8,976	\$10,092	\$56,862	\$179,215	\$347,845	\$532,644	\$193,184	\$284,857	\$231,078	\$174,882	\$197,093	\$331,982	\$331,223

Figure 54. Charger TCO Output Sheet – Lifetime EV Charger Costs Detailed Graph

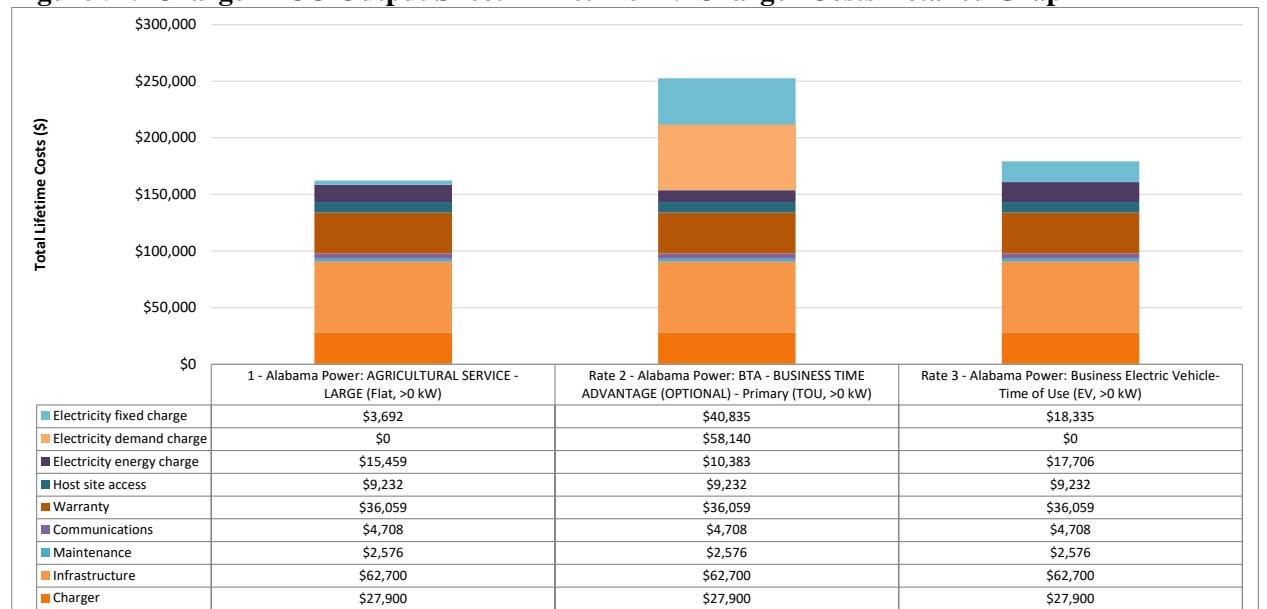
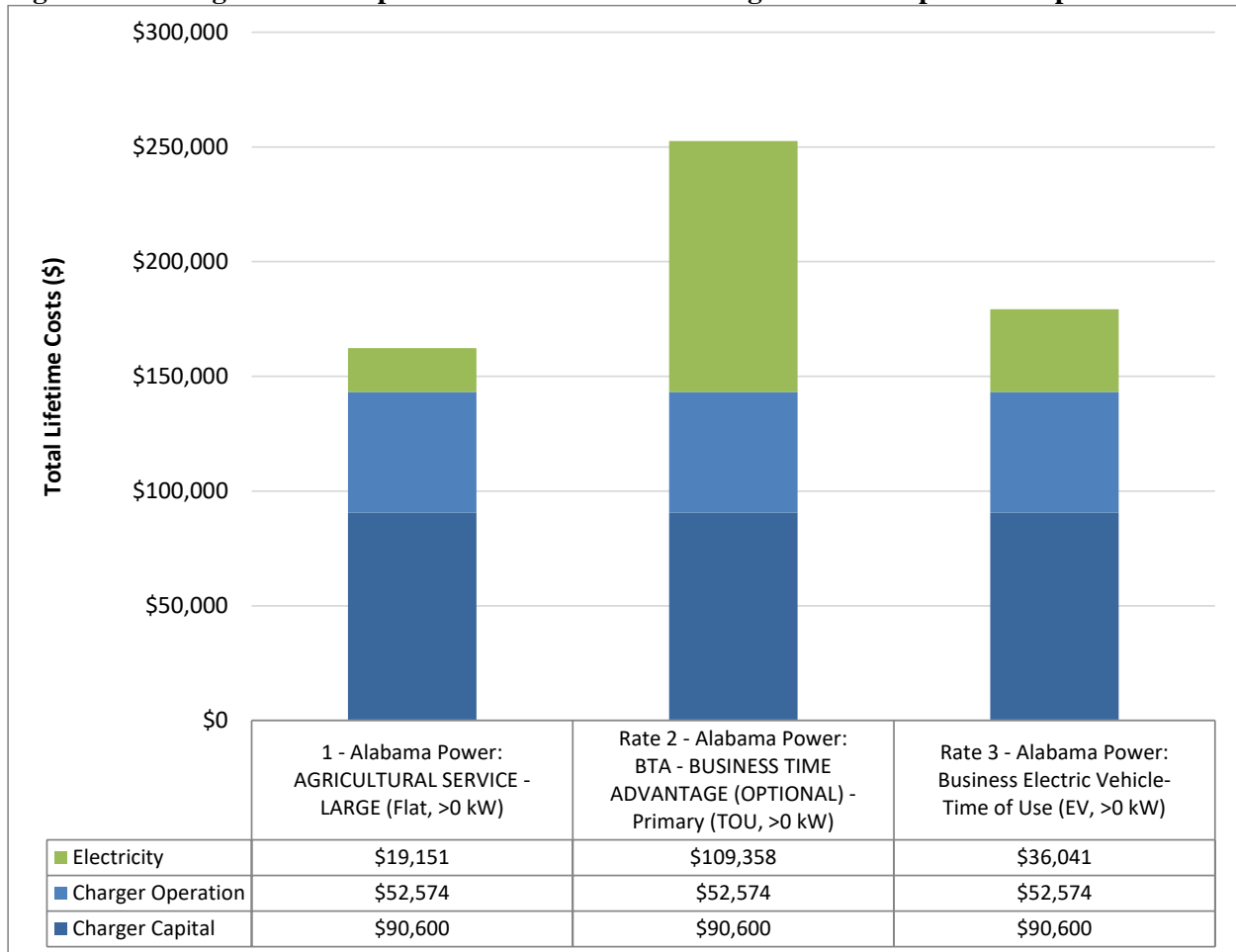


Figure 55. Charger TCO Output Sheet – Lifetime EV Charger Costs Simplified Graph



2.16 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 56). 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 hoteling, which is for long-haul trucks that idle overnight.

Figure 56. IR Sheet – LDV IR Inputs

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

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

2.17 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 57. 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
Acquisition Cost											
Light-Duty (LD) Fleet IR Equipment			\$9,000	\$9,000	\$15,000		\$43,000	\$52,000	\$58,000		\$25,000
Heavy-Duty (HD) Fleet IR Equipment			\$18,000	\$17,000	\$25,000	\$100,000	\$80,000	\$98,000	\$105,000	\$50	\$25,000
Annual Idling Operating Cost - Private Station Fueling											
LD Fleet	\$16,997		\$12,258		\$14,152		\$13,754	\$9,015	\$9,072		
HD Fleet		\$32,348	\$22,718		\$27,397	\$7,845	\$25,693	\$16,063	\$17,739	\$14,364	\$13,339
Annual Idling Operating Savings - Private Station Fueling											
Compared to Gasoline LD Fleet Idling			\$4,739		\$2,844		\$3,242	\$7,981	\$7,924		
Compared to Diesel HD Fleet Idling			\$9,630		\$4,951	\$24,502	\$6,655	\$16,285	\$14,609	\$17,983	\$19,008
Simple Payback (years)											
LD Passenger Car IR Equipment			1.9		5.3		13.3	6.5	7.3		
HD Combination Long-Haul Truck IR Equipment			1.9		5.0	4.1	12.0	6.0	7.2	0.0	1.3

Figure 58. 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
Annual Well-to-Wheels Idling Petroleum Use (barrels)											
LD Petroleum Use	109.2		77.3	109.2	84.8		81.3	49.5	55.7		
HD Petroleum Use		432.8	299.6	432.8	301.3	97.2	277.9	144.8	173.8	162.5	162.5
Annual Well-to-Wheels Idling GHGs (short tons)											
LD GHGs	63.5		45.0	63.5	49.4		47.3	28.8	32.4		
HD GHGs		245.4	169.9	245.4	170.9	55.1	157.6	82.1	98.5	97.9	97.9
Annual Vehicle Operation Idling Air Pollutants (lb)											
LD Passenger Car Fleet											
CO	0.78		2.05	0.78	0.55		0.55	1.82	0.26		
NOx	0.11		0.58	0.11	0.08		0.08	0.55	0.04		
PM10	0.09		0.11	0.09	0.07		0.07	0.09	0.03		
PM2.5	0.08		0.10	0.08	0.06		0.06	0.08	0.03		
VOC	0.02		0.14	0.02	0.02		0.02	0.14	0.01		
SOx	1.50		1.06	1.50	1.17		1.12	0.68	0.76		
HD Combination Long-Haul Truck Fleet											
CO		1.14	2.46	1.14	0.75	154.76	0.70	2.03	0.38	1.14	1.14
NOx		2.13	1.99	2.13	1.40	122.32	1.32	1.18	0.70	2.13	2.13
PM10		0.07	0.10	0.07	0.05	7.99	0.04	0.08	0.02	0.07	0.07
PM2.5		0.07	0.10	0.07	0.04	7.35	0.04	0.07	0.02	0.07	0.07
VOC		0.19	0.27	0.19	0.13	32.38	0.12	0.20	0.06	0.19	0.19
SOx		2.69	1.86	2.69	1.87	0.60	1.72	0.90	1.08	1.01	1.01

Figure 59. 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) & Fuel Operated Air	(Battery) & Fuel Managemen	Truck Stop Electrification - Single System	Shore Power
Annual Idling Petroleum Use Externality Costs										
LD Petroleum Use	\$1,716		\$1,215	\$1,716	\$1,334		\$1,278	\$777	\$875	
HD Petroleum Use		\$6,802	\$4,709	\$6,802	\$4,736	\$1,528	\$4,368	\$2,276	\$2,731	\$2,554
Annual Idling GHG Externality Costs										
LD GHGs	\$2,402		\$1,701	\$2,402	\$1,867		\$1,789	\$1,088	\$1,225	
HD GHGs		\$9,279	\$6,425	\$9,279	\$6,461	\$2,085	\$5,959	\$3,104	\$3,726	\$3,703
Annual Idling Air Pollutant Externality Costs										
LD Passenger Car Fleet										
CO	\$0		\$0	\$0	\$0		\$0	\$0	\$0	
NOx	\$1		\$7	\$1	\$1		\$1	\$6	\$0	
PM10	\$2		\$3	\$2	\$2		\$2	\$2	\$1	
PM2.5	\$21		\$26	\$21	\$15		\$15	\$20	\$7	
VOC	\$0		\$3	\$0	\$0		\$0	\$2	\$0	
SOx	\$92		\$65	\$92	\$71		\$68	\$42	\$47	
Light-Duty Total	\$117		\$103	\$117	\$89		\$86	\$73	\$55	
HD Combination Long-Haul Truck Fleet										
CO		\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
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
Total Petroleum, GHG, and Air Pollutant Externality Costs										
LD Fleet	\$4,234		\$3,019	\$4,234	\$3,290		\$3,153	\$1,938	\$2,155	
HD Fleet		\$16,139	\$11,197	\$16,139	\$11,236	\$7,703	\$10,363	\$5,421	\$6,477	\$6,315
Total Petroleum, GHG, and Air Pollutant Cost Savings										
LD Fleet			\$1,215	\$0	\$945		\$1,081	\$2,296	\$2,079	
HD Fleet			\$4,942	\$0	\$4,903	\$8,436	\$5,776	\$10,718	\$9,661	\$9,824
Annual Operating Savings with Externality Cost Savings										
Compared to Gasoline LD Fleet			\$5,954		\$3,789		\$4,323	\$10,277	\$10,003	
Compared to Diesel HD Fleet			\$14,572		\$9,854	\$32,938	\$12,430	\$27,002	\$24,270	\$27,807
Simple Payback with Externality Costs (years)										
LD Passenger Car Fleet			1.5		4.0		9.9	5.1	5.8	
HD Single Unit Short-Haul Truck Fleet			1.2		2.5	3.0	6.4	3.6	4.3	0.0

Figure 60. IR Output Sheet – LDV Simple Payback with and without Externalities Graph

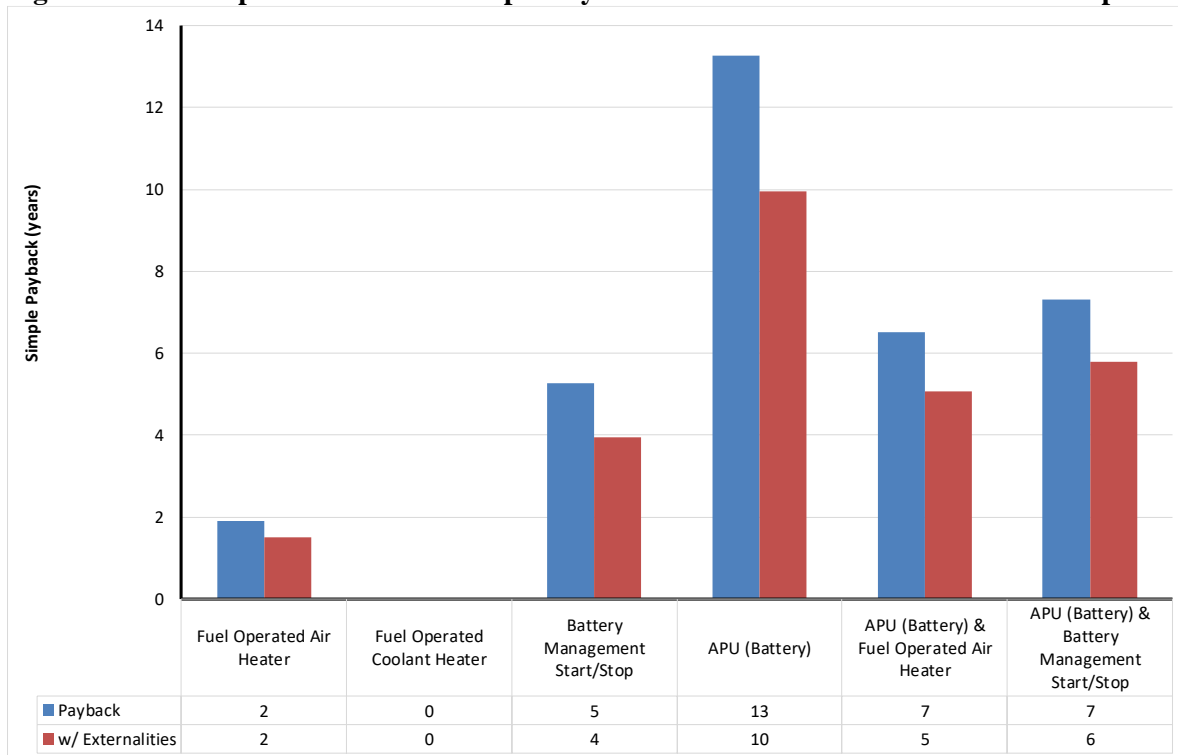


Figure 61. IR Output Sheet – Annual HDV Energy Use and GHGs Summary Graph

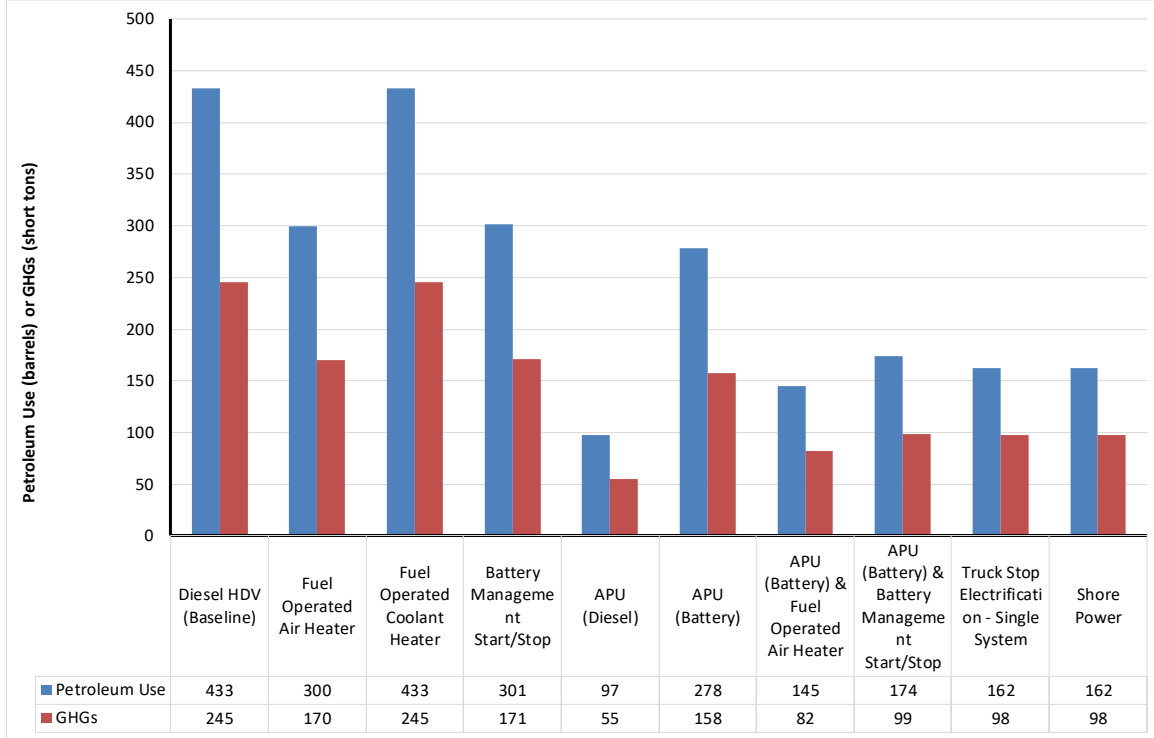


Figure 62. IR Output Sheet – Annual LDV Air Pollutant Emissions Summary Graph

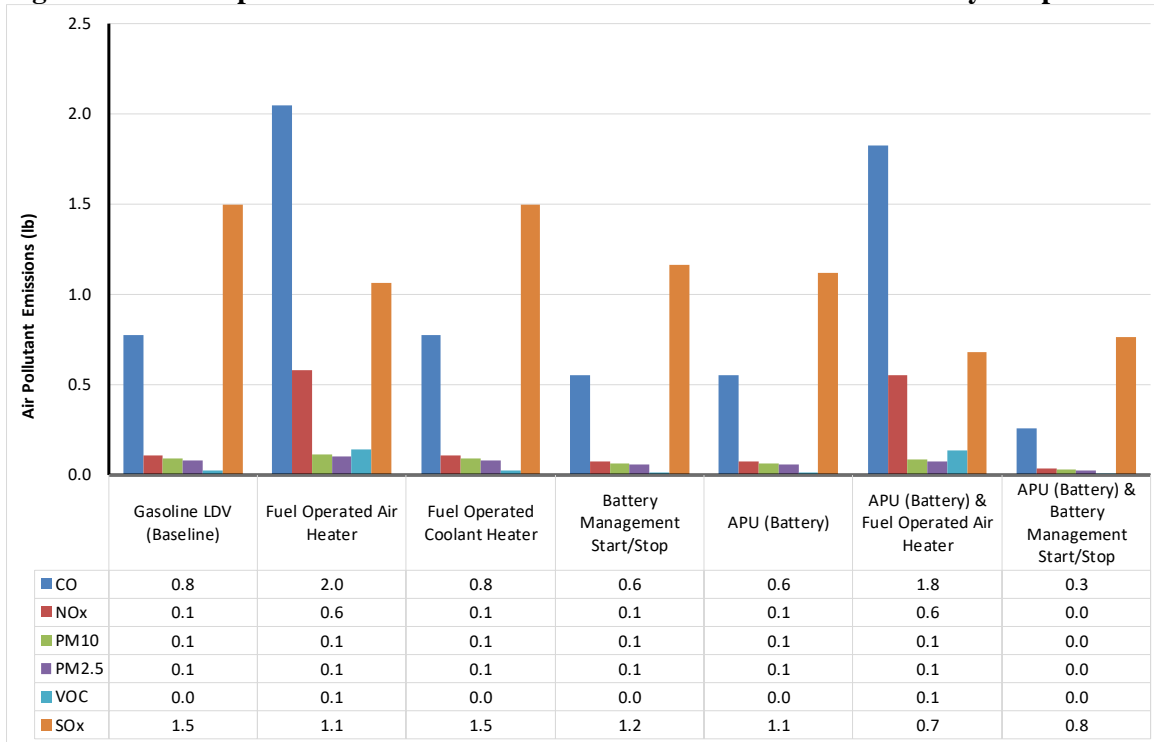


Figure 63. IR Output Sheet – Annual HDV Annual Externality Costs Graph

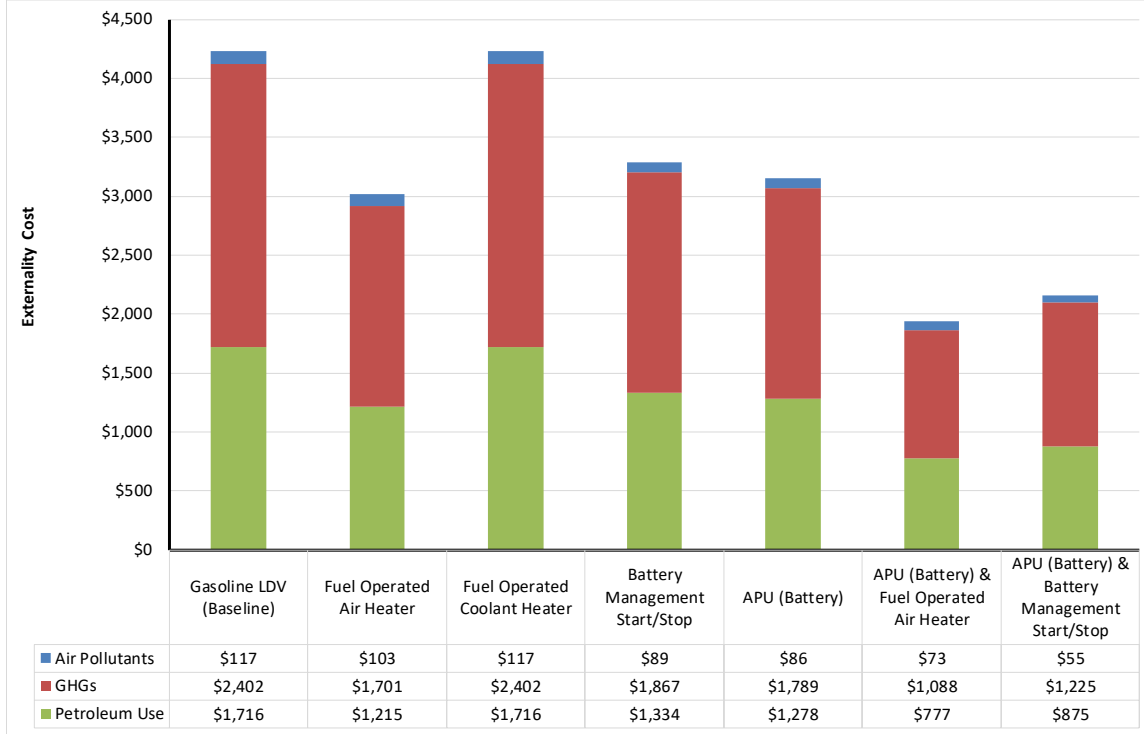
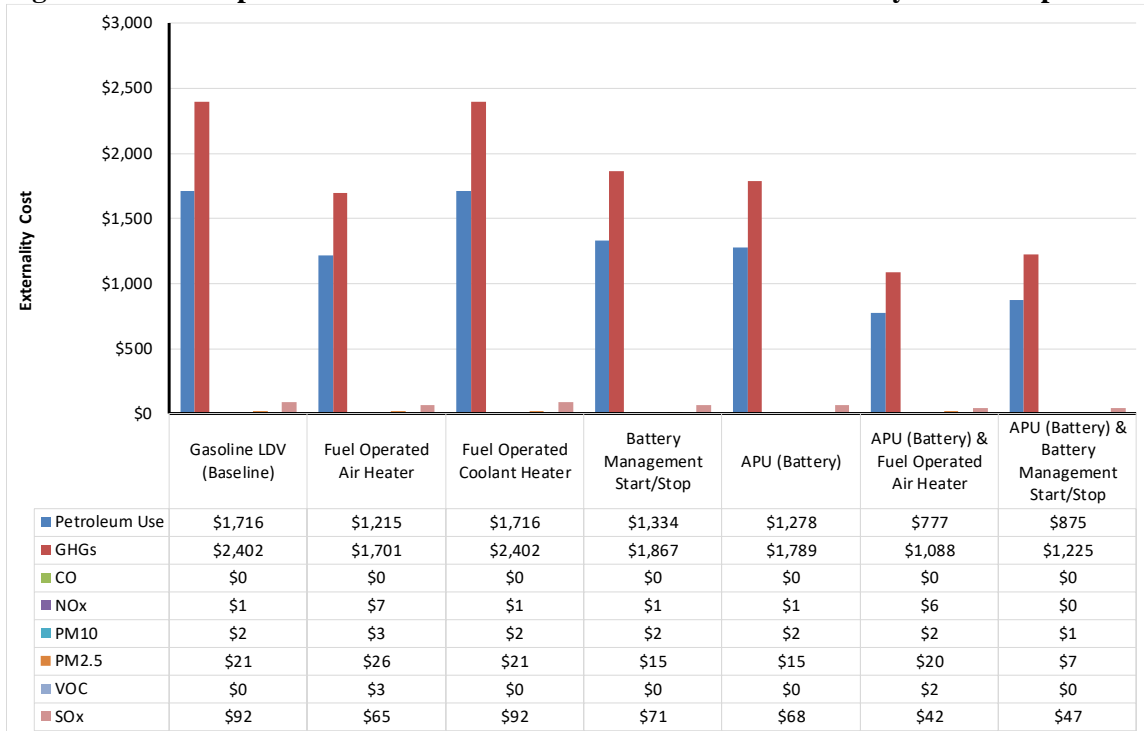


Figure 64. IR Output Sheet – Annual LDV Annual Detailed Externality Costs Graph



2.18 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 65), the IR equipment for on-road vehicles, and the Payback AFVs for the off-road equipment (Figure 66). This will alter the lookup tables, which AFLEET Tool references for the default data of key inputs in the various sheets. Figure 67 shows an example of one look up table. Also mentioned previously, the user can input custom electricity mixes on this sheet (Figure 68). Figure 69 shows where the user can input custom EV utility rates. 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 65. 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 66. 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 67. Background Data Sheet - AFLEET Look Up Tables - New Vehicle Purchase Price

Vocation Type	MOVES Category	Gasoline	Diesel	Gasoline Plug-in Hybrid Electric Vehicle (HEV)	Gasoline Extended Range Electric Vehicle (PHEV)	Gasoline Extended Range Electric Vehicle (EREV)	Gasoline All-Electric Vehicle (EV)	Gasoline Gaseous Hydrogen Cell Vehicle (FCV)	Diesel Hybrid Electric Vehicle (HEV)	Diesel Hydraulic Hybrid (HHV)	Biodiesel (B20)	Biodiesel (B100)	Ethanol (E85)	Propane (LPG)	Compressed Natural Gas (CNG)	Liquefied Natural Gas (LNG)	LNG / Diesel Pilot Ignition
				Gasoline	Diesel	Gasoline Hybrid Electric Vehicle (HEV)	Gasoline Extended Range Electric Vehicle (PHEV)	Gasoline Extended Range Electric Vehicle (EREV)	Gasoline All-Electric Vehicle (EV)	Gasoline Gaseous Hydrogen Cell Vehicle (FCV)	Diesel Hybrid Electric Vehicle (HEV)	Diesel Hydraulic Hybrid (HHV)	Biodiesel (B20)	Biodiesel (B100)	Ethanol (E85)	Propane (LPG)	Compressed Natural Gas (CNG)
Long Haul Freight Truck	Combination Long-Haul Truck	\$100,000	\$100,000						\$140,000		\$100,000	\$100,000			\$165,000	\$150,000	\$190,000
Regional Haul Freight Truck	Combination Short-Haul Truck	\$90,000	\$90,000						\$137,500		\$90,000	\$90,000			\$130,000	\$120,000	\$155,000
Delivery Straight Truck	Single Unit Long-Haul Truck	\$75,000	\$75,000						\$115,000		\$75,000	\$75,000			\$140,000	\$125,000	\$170,000
Delivery Step Van	Single Unit Short-Haul Truck	\$65,000	\$65,000						\$105,000		\$65,000	\$65,000			\$135,000	\$120,000	\$145,000
Dump Truck		\$80,000	\$80,000				\$150,000				\$80,000	\$80,000			\$140,000	\$130,000	\$150,000
Bucket/Aerial Truck		\$115,000	\$115,000								\$115,000	\$115,000			\$215,000	\$205,000	\$235,000
Snow Plow/Sander		\$100,000	\$100,000				\$355,000				\$100,000	\$100,000			\$170,000	\$160,000	\$190,000
Sewer Cleaner		\$385,000	\$385,000								\$385,000	\$385,000			\$410,000	\$410,000	\$410,000
Street Sweeper		\$190,000	\$190,000								\$190,000	\$190,000			\$265,000	\$265,000	\$265,000
Refuse Truck	Refuse Truck	\$210,000	\$210,000				\$670,000		\$260,000	\$250,000	\$210,000	\$210,000			\$260,000	\$250,000	\$250,000
Transit Bus	Transit Bus	\$300,000	\$300,000				\$750,000	\$1,800,000	\$510,000		\$300,000	\$300,000			\$360,000	\$350,000	\$350,000
School Bus	School Bus	\$90,000	\$90,000						\$150,000		\$90,000	\$90,000		\$105,000	\$140,000	\$140,000	\$130,000
Shuttle/Paratransit Bus	Shuttle/Paratransit Bus	\$65,000	\$65,000						\$120,000		\$65,000	\$65,000		\$75,000	\$90,000	\$90,000	\$90,000
Medium-Duty Pickup Truck	Light Commercial Truck	\$36,000	\$46,500								\$46,500	\$46,500	\$36,000	\$44,000	\$48,500	\$48,500	\$48,500
Utility Cargo Van	Utility Cargo Van	\$34,500	\$46,500				\$69,500				\$46,500	\$46,500	\$34,500	\$44,500	\$50,500	\$50,500	\$50,500
Shuttle/Paratransit Van	Shuttle/Paratransit Van	\$38,000	\$50,000								\$50,000	\$50,000	\$38,000	\$44,500	\$48,000	\$48,000	\$48,000
Light-Duty Pickup Truck	Light-Duty Pickup Truck	\$32,000	\$39,500								\$39,500	\$39,500	\$32,000	\$38,500	\$43,500	\$43,500	\$43,500
SUV	Passenger Truck	\$27,500	\$30,000	\$31,500					\$59,000	\$66,000	\$30,000	\$30,000	\$27,500	\$33,500	\$40,000	\$40,000	\$40,000
SUV - Taxi	Passenger Truck	\$27,500	\$30,000	\$31,500					\$59,000	\$66,000	\$30,000	\$30,000	\$27,500	\$33,500	\$40,000	\$40,000	\$40,000
Car	Passenger Car	\$20,000	\$22,500	\$23,000	\$32,500	\$34,000	\$30,000	\$58,500	\$58,500	\$58,500	\$22,500	\$22,500	\$20,000	\$26,000	\$27,000	\$27,000	\$27,000
Car - Taxi	Passenger Car	\$20,000	\$22,500	\$23,000	\$32,500	\$34,000	\$30,000	\$58,500	\$58,500	\$58,500	\$22,500	\$22,500	\$20,000	\$26,000	\$27,000	\$27,000	\$27,000
Car - Police	Passenger Car	\$20,000	\$22,500	\$23,000	\$32,500	\$34,000	\$30,000	\$58,500	\$58,500	\$58,500	\$22,500	\$22,500	\$20,000	\$26,000	\$27,000	\$27,000	\$27,000
Maintenance Utility Vehicle	Maintenance Utility Vehicle	\$14,000	\$14,000				\$19,000				\$0	\$0	\$14,000				
Other	Other																

Figure 68. Background Data Sheet – GREET Fleet Specifications – Electricity Mix

	U.S. Average Mix	Alaska Systems Coordinating Council (ASCC)	Florida Reliability Coordinating Council (FRCC)	Hawaiian Islands Coordinating Council (HICC)	Midwest Reliability Organization (MRO)	Northeast Power Coordinating Council (NPCC)	Reliability First Corporation (RFC)	SERC Reliability Corporation (SERC)	Southwest Power Pool (SPP)	Texas Regional Entity (TRE)	Western Electricity Coordinating Council (WECC)	User Mix
		Alaska Systems Coordinating Council (ASCC)	Florida Reliability Coordinating Council (FRCC)	Hawaiian Islands Coordinating Council (HICC)	Midwest Reliability Organization (MRO)	Northeast Power Coordinating Council (NPCC)	Reliability First Corporation (RFC)	SERC Reliability Corporation (SERC)	Southwest Power Pool (SPP)	Texas Regional Entity (TRE)	Western Electricity Coordinating Council (WECC)	User Mix
Residual oil	0.6%	12.6%	1.7%	70.3%	0.2%	1.4%	0.2%	0.4%	1.3%	0.1%	0.2%	0.6%
Natural gas	26.2%	52.7%	60.2%	0.0%	2.6%	50.1%	15.9%	18.8%	22.7%	41.3%	32.5%	26.2%
Coal	40.6%	9.6%	23.3%	13.7%	61.8%	2.6%	51.3%	49.3%	56.0%	36.0%	25.4%	40.6%
Nuclear power	19.9%	0.0%	12.3%	0.0%	12.2%	28.7%	28.3%	27.3%	4.1%	12.3%	7.9%	19.9%
Biomass	0.3%	0.8%	0.5%	3.2%	0.6%	0.6%	0.1%	0.4%	0.0%	0.2%	0.2%	0.3%
Others (Wind, Solar, Hydro, etc)	12.4%	24.3%	2.0%	12.8%	22.6%	16.6%	4.1%	3.7%	15.9%	10.0%	33.8%	12.4%

Figure 69. Background Data Sheet – EV Rate – Custom Rate Data

Full Name	Rate type	Fixed rate (\$/month)	'Summer' Peak Energy (\$/kWh)			'Winter' Non-Peak Energy (\$/kWh)			'Summer' Peak Demand (\$/kW)			'Winter' Demand (\$/kW)				
			On-peak	Mid-peak	Off-peak	On-peak	Mid-peak	Off-peak	Flat rate	On-Peak	Mid-Peak	Off-Peak	Flat rate	On-Peak	Mid-Peak	Off-Peak
Custom: Rate 1 (Flat)	Flat	\$ 1,000.00	0	0	0.1	0	0	0.1	\$5.00	\$0.00	\$0.00	\$0.00	\$4.00	\$0.00	\$0.00	\$0.00
Custom: Rate 2 (TOU)	TOU	\$ 500.00	0.3	0.2	0.1	0.2	0.15	0.1	\$5.00	\$10.00	\$5.00	\$2.00	\$4.00	\$8.00	\$3.00	\$1.00
Custom: Rate 3 (EV)	EV	\$ 250.00	0	0	0.05	0	0	0.05	\$5.00	\$0.00	\$0.00	\$0.00	\$4.00	\$0.00	\$0.00	\$0.00
Custom: Rate 4 (Flat)	Flat	\$ 1,000.00	0	0	0.1	0	0	0.1	\$5.00	\$0.00	\$0.00	\$0.00	\$4.00	\$0.00	\$0.00	\$0.00
Custom: Rate 5 (TOU)	TOU	\$ 500.00	0.3	0.2	0.1	0.2	0.15	0.1	\$5.00	\$10.00	\$5.00	\$2.00	\$4.00	\$8.00	\$3.00	\$1.00
Custom: Rate 6 (EV)	EV	\$ 250.00	0	0	0.05	0	0	0.05	\$5.00	\$0.00	\$0.00	\$0.00	\$4.00	\$0.00	\$0.00	\$0.00

3. REFERENCES

Anenberg, S., et al., 2017, “Impacts and mitigation of excess diesel-related NO_x emissions in 11 major vehicle markets,” *Nature* 545: 467-471

Argonne National Laboratory, 2022a, GREET Fuel-Cycle Model – GREET1_2022 version, <http://greet.es.anl.gov>.

Argonne National Laboratory, 2022b, GREET Vehicle-Cycle Model – GREET2_2022 version, <http://greet.es.anl.gov>.

Arneja, P. (2019). Battery Electric Bus and Truck Charging Calculator (Version 4.0). California Air Resources Board.

Cai, H., A. Burnham, M. Wang, W. Hang, A. Vyas, 2015, The GREET Model Expansion for Well-to-Wheels Analysis of Heavy-Duty Vehicles, ANL/ESD-15/9 Rev. 1, Argonne National Laboratory, <https://greet.es.anl.gov/publication-heavy-duty>.

Cai, H., A. Burnham, R. Chen, M. Wang, 2017, “Wells to Wheels: Environmental Implications of Natural Gas as A Transportation Fuel,” *Energy Policy* 109: 565-578,

California Energy Commission, 2023, California Retail Fuel Outlet Annual Reporting (CEC-A15) Results, 2020 Reporting Year, <https://www.energy.ca.gov/data-reports/energy-almanac/transportation-energy/california-retail-fuel-outlet-annual-reporting>.

EIA, 2022, Annual Electric Power Industry Report, Form EIA-861. <https://www.eia.gov/electricity/data/eia861/>.

EPA, 2015, Motor Vehicle Emission Simulator (MOVES) – MOVES2014a version. <https://www.epa.gov/moves>.

EPA, 2022, Motor Vehicle Emission Simulator (MOVES) – MOVES3.0.3 version. <https://www.epa.gov/moves>.

EV Project, 2013, EV Project Quarterly and Annual Report Data, INL, <https://avt.inl.gov/project-type/data>.

Interagency Working Group on Social Cost of Carbon, 2015, Technical Support Document: - Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis - Under Executive Order 12866. The White House. Revision July 2015. <https://www.whitehouse.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf>

Islam, E., R. Vijayagopal, A. Rousseau, 2022, A Comprehensive Simulation Study to Evaluate Future Vehicle Energy and Cost Reduction Potential, Report to the US Department of Energy,

Contract ANL/ESD-22/6, <https://vms.taps.anl.gov/research-highlights/u-s-doe-vto-hfto-r-d-benefits/>

Iyer, R., et al., 2021, Vehicle-Cycle Inventory for Medium- and Heavy-Duty Vehicles, ANL/ESD-21/18, Argonne National Laboratory, https://greet.es.anl.gov/publication-mhdv_vc.

Jaramillo P. and N. Muller, 2016, "Air pollution emissions and damages from energy production in the U.S.: 2002—2011," Energy Policy 90: 202 - 211.

Michalek, J.J., M. Chester, P. Jaramillo, C. Samaras, C-S.N. Shiau, and L.B. Lave, 2011, Valuation of Plug-In Vehicle Life-Cycle Air Emissions and Oil Displacement Benefits. PNAS 1804 (40): 16554-16558

Mintz, M., et al., 2018, Agent-Based Transportation Energy Analysis Model: Methodology and Initial Results, Argonne National Laboratory, December 7.

Moawad, A., Kim, N., Shidore, N., Rousseau, A., 2016, "Assessment of Vehicle Sizing, Energy Consumption and Cost through Large Scale Simulation of Advanced Vehicle Technologies", Report to the US Department of Energy, Contract ANL/ESD-15/28. http://www.autonomie.net/publications/fuel_economy_report.html

Levinson, M., et al., 2021, New York State Clean Transportation Roadmap, Final Report, Report Number 22-14, Prepared for New York State Energy Research and Development Authority, NYSERDA Contract 150855, December 2021.

Muller, N., 2017, The Air Pollution Emission Experiments and Policy Analysis Model (AP2), Marginal Damages (2011) from Holland, Mansur, Muller, Yates AER forthcoming.xlsx, <https://sites.google.com/site/nickmullershomepage/home/ap2-apeep-model-2>

Ruder, A., 2019, New York State Electric Vehicle Charging Station Data, NYSERDA, personal communication, August 2.

Ryskamp, R., 2020, Chassis Dynamometer Evaluation of Propane Powered MD to HD Vehicles, Propane, Gasoline, and Diesel Ford F-750 Preliminary Results, West Virginia University, January 17.

Sandhu, G., et al., 2017, In-Use Emission Rates for MY 2010+ Heavy-Duty Diesel Vehicles, CRC On-Road Vehicle Emissions Workshop

Wood, E., et al., 2018, Charging Electric Vehicles in Smart Cities: An EVI-Pro Analysis of Columbus, Ohio, NREL/TP-5400-70367, NREL.

Zimny-Schmitt, D., 2022, U.S. Utility Rate Database, National Renewable Energy Laboratory, December, https://openei.org/wiki/Utility_Rate_Database.