“AFLEET Tool” To Analyze the Costs and Benefits of Alternative Fuel Vehicles

Andy Burnham
Argonne National Laboratory
November 12, 2013

Agenda

- **AFLEET Tool Background**
- **AFLEET Demo #1**
  - Simple Payback and TCO Calculators
- **AFLEET Demo #2**
  - Fleet Energy & Emissions Footprint Calculator

AFLEET Tool Background

Past Clean Cities Tool Development at Argonne

- **In 1998, DOE & EPA co-sponsored AirCRED**
  - Estimated ozone precursor & carbon monoxide emission credits from AFVs
    - For use in State Implementation Plans
- **In 2009, developed Clean Cities AOI 4 Emissions Benefit Tool**
  - Estimated GHG & air pollutant emission benefits of Recovery Act grant proposals
- **Also in 2009, developed GREET Fleet Footprint Calculator**
  - Estimated petroleum use & GHG footprints of medium/heavy duty vehicles & off-road equipment

Motivation and Development of AFLEET Tool

- **Coordinators developing "Green Fleet" certification & consulting services**
  - Looking for tool to estimate the costs & benefits of AFVs
- **Focus was to build off methodologies from existing tools**
  - AirCRED
  - GREET Fleet
  - EPA's Diesel Emission Quantifier (DEQ)
  - NREL's Vehicle and Infrastructure Cash-Flow Evaluation (VICE) Model
  - AFDC's Vehicle Cost Calculator
- **Developed in Microsoft Excel**
  - Allows easier interface with fleet data

AFLEET Tool is Available for Download

- **Examines light-duty & heavy-duty vehicle**
  - Petroleum use
  - GHG emissions
  - Air pollutant emissions
  - Cost of ownership

- **Contains 15 fuel/vehicle technologies**
  - Conventional: gasoline, diesel
  - Hybrid: gasoline HEV, diesel HEV, diesel hydraulic hybrid
  - Plug-in electric: PHEV, EREV, EV
  - Alternative fuel: B20, B100, E85, LPG, CNG, LNG, LNG/diesel pilot ignition

- **AFLEET Tool & its user manual available at:**
  http://greet.es.anl.gov/afleet

AFLEET Tool's Major Data Sources

- **Argonne's GREET model**
  - Well-to-wheel petroleum use & GHG coefficients & fuel economy data
- **EPA's Motor Vehicle Emission Simulator (MOVES)**
  - Vehicle operation air pollutant emission factors by state
    - LDV = passenger car, passenger truck, light commercial truck
    - HDV = school bus, transit bus, refuse truck, single unit (short/long haul) trucks, combination (short/long haul) trucks
- **Clean Cities Recovery Act Project quarterly data**
  - Purchase price & fuel economy data
- **Clean Cities Alternative Fuel Price Report**
  - Public station fuel prices

AFLEET Tool's Structure

- **AFLEET Tool has 9 sheets**
  - Instructions
  - Inputs
  - Payback
  - Payback Outputs
  - TCO
  - TCO Outputs
  - Footprint
  - Footprint Outputs
  - Background Data

- **Cell color scheme**
  - Yellow cells = key assumptions users can change with their data
  - Orange cells = key options users will select via drop-down menu
  - White cells = calculations and secondary assumptions

AFLEET Tool's Calculation Methods - Simple Payback

- **Tool has 3 calculation methods & which to use depends on your goals**
  - Simple Payback Calculator
  - Total Cost of Ownership Calculator
  - Fleet Energy and Emissions Footprint Calculator

- **Simple Payback Calculator**
  - Simple payback of purchasing new AFV vs. conventional counterpart
    - Uses incremental acquisition & annual operating costs
      - Operating costs = fuel, DEF & maintenance
  - Average annual petroleum use, GHGs & air pollutant emissions

AFLEET Tool's Calculation Methods - TCO and Footprint

- **Total Cost of Ownership Calculator**
  - Net present value of operating & fixed costs over the years of planned ownership of a new vehicle
    - Discounted cash flow analysis
      - Fixed costs = financing, depreciation, insurance, license & registration
      - Operating costs = fuel, DEF & maintenance
    - Lifetime petroleum use, GHGs & air pollutant emissions

- **Fleet Energy and Emissions Footprint Calculator**
  - Annual petroleum use, GHGs & air pollutant emissions of existing & new vehicles
    - Older vehicles have higher air pollutant emission rates than newer ones

Fleet Analysis with AFLEET Tool - Inventory Data

- **For new purchase analysis & footprinting, fleet inventory data is important**
  - Make, model & model year
  - Vocation description
  - Mileage
  - Fuel use
  - Fuel and maintenance costs

- **If fleet is large & heterogeneous, data helps target vehicles for replacement**
  - Replacing high fuel use vehicles
    - Faster payback with lower cost fuel
    - Larger opportunity for petroleum and GHG reductions
  - Replacing older high mileage vehicles
    - Larger air pollutant emission benefits

Fleet Analysis with AFLEET Tool - Other Data

- **Other data useful for analysis**
  - Typical replacement cycles
    - Age and/or mileage
      - Typically depends on vehicle type
    - To target vehicles for replacement
  - Discount rate (i.e. required rate of return)
    - Private business vs. municipality (vs. individual)
  - Nearby public fuel availability and prices
    - Current version doesn't include private fueling infrastructure costs
      - Important consideration for fuels like CNG, LNG & LPG

Using Simple Payback and TCO Calculators to Compare Potential Acquisitions

AFLEET Tutorial - Simple Payback and TCO Calculators

- **1st step: enter key inputs on "Inputs" sheet**
  - State and vehicle type (via drop-down)
  - # of vehicles, VMT, MPGGE, and purchase price
    - Default and MPDGE reference values available (to the side of below tables)
  - Can simulate both an LDV and HDV

Primary Vehicle Location				
State	ILLINOIS			
Heavy-Duty Vehicle Information				
Vehicle Type	Refuse Truck			
Heavy-Duty Fuel Type	**Number of Heavy-Duty Vehicles**	**Annual Vehicle Mileage**	**Fuel Economy (MPGGE)**	**Purchase Price ($/Vehicle)**
Gasoline	0	0	1.3	$0
Diesel	10	25,000	1.5	$210,000
All-Electric Vehicle (EV)	0	23,400	4.2	$670,000
Diesel Hybrid Electric Vehicle (HEV)	10	25,000	1.9	$260,000
Diesel Hydraulic Hybrid (HHV)	10	25,000	1.9	$250,000
Biodiesel (B20)	0	23,400	1.5	$210,000
Biodiesel (B100)	0	23,400	1.5	$210,000
Ethanol (E85)	0	0	1.3	$0
Propane (LPG)	0	0	1.4	$0
Compressed Natural Gas (CNG)	10	25,000	1.3	$260,000
Liquefied Natural Gas (LNG)	0	23,400	1.3	$250,000
LNG / Diesel Pilot Ignition	0	0	1.5	$0

AFLEET Tutorial - Simple Payback and TCO Calculators

- **2nd step: enter fuel prices on "Inputs" sheet**
  - Values in respective fuel unit

Fuel and DEF Price	Fuel Unit	$/Fuel Unit
Gasoline	gasoline gallon	$3.66
Diesel	diesel gallon	$4.15
Electricity	kWh	$0.06
B20	B20 gallon	$4.16
B100	B100 gallon	$4.55
E85	E85 gallon	$3.40
Propane	LPG gallon	$2.39
CNG	CNG GGE	$2.20
LNG	LNG gallon	$1.53
DEF	DEF gallon	$2.80

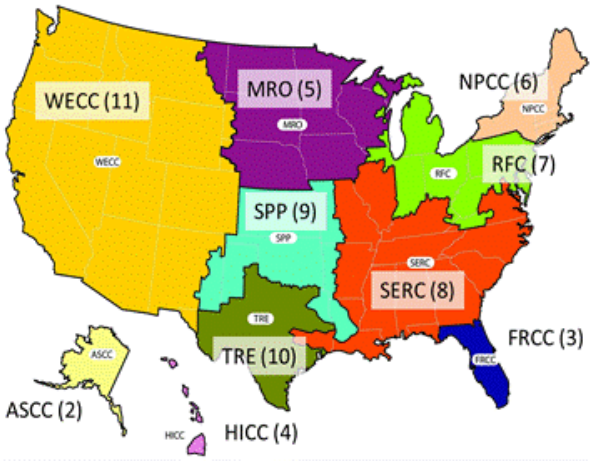
- **3rd step: enter TCO inputs on "Inputs" sheet**

Light-Duty Vehicle Information		
Years of Planned Ownership	years	8
Heavy-Duty Vehicle Information		
Years of Planned Ownership	years	12
Financial Assumptions		
Loan	yes/no	Yes
Loan Term	years	5
Interest Rate	%	4.14%
Percent Down Payment	%	20.00%
Discount Factor	%	5.00%

AFLEET Tutorial - Simple Payback and TCO Calculators

- **4th step: adjust fuel production assumptions on "Inputs" sheet**

Biodiesel Feedstock Source	1 - Soy	1	
	2 - Algae		
Ethanol Feedstock Source	1 - Corn	1	
	2 - Switchgrass		
CNG Feedstock Source	1 - North American NG	1	
	2 - Non-North American NG		
	3 - Landfill Gas		
LNG Feedstock Source	1 - North American NG	1	
	2 - Non-North American NG		
	3 - Landfill Gas		
North American NG Feedstock Source		Conventional	Shale
		66%	34%
LPG Feedstock Source		NG	Petroleum
		69%	31%
Source of Electricity for Plug-in Hybrid Electric Vehicles (PHEVs) and All-Electric Vehicles (			
	1 - Average U.S. Mix	7	
	2 to 11 - EIA Region Mix (see map)		
	12 - User Defined (go to 'Background Data' sheet)		



AFLEET Tutorial - Simple Payback and TCO Calculators

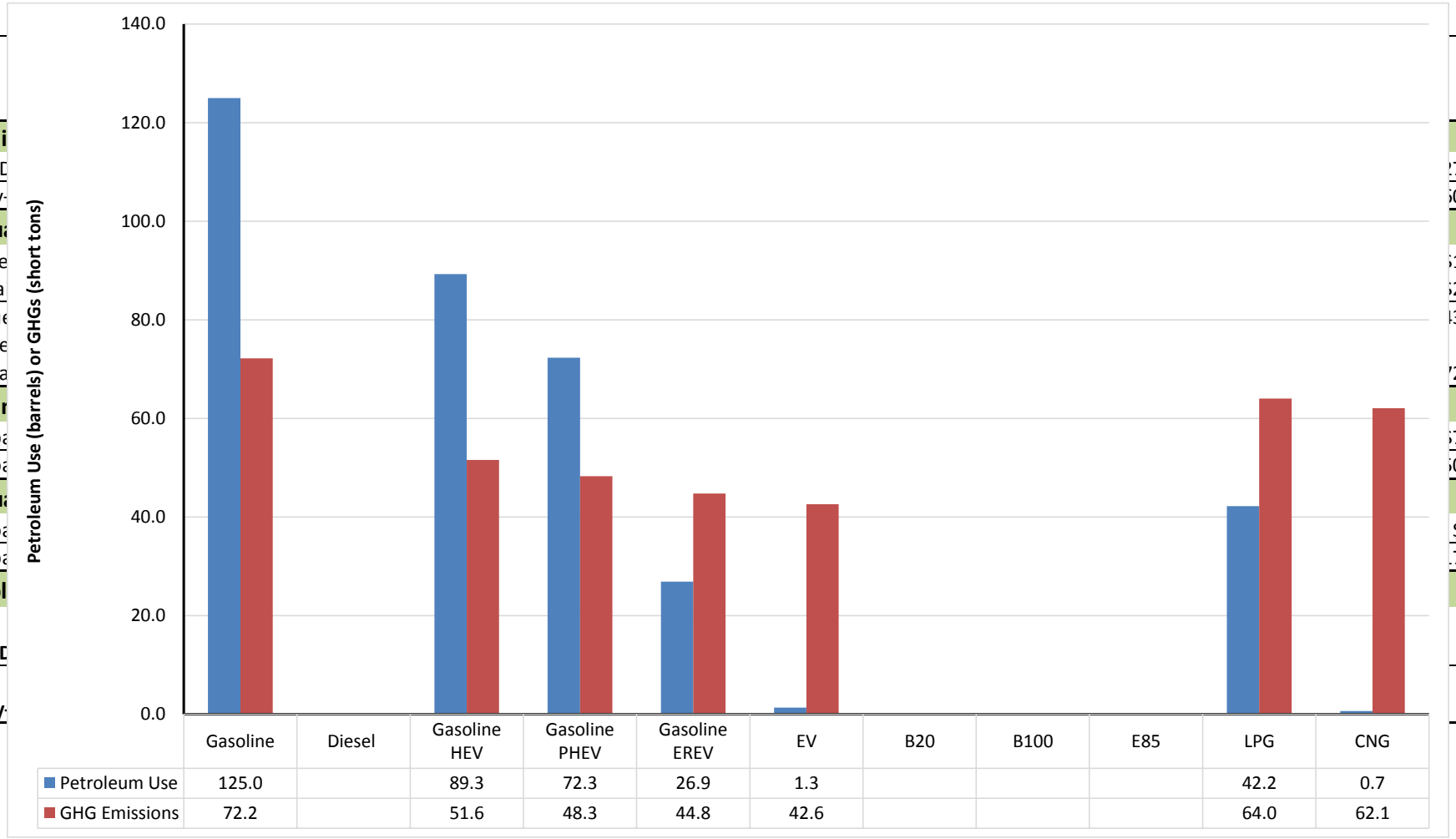
- **5th step: enter additional PHEV and EREV data on "Payback" sheet**
  - CD "EV mode" fuel consumption
  - CD range
  - Charges per day and days driven per week
  - Other secondary assumptions are on this sheet as well

	Gasoline	Diesel	Gasoline HEV	Gasoline PHEV	Gasoline EREV
Light-Duty Vehicle Inputs					
Vehicle Type	Passenger Car				
Number of LDVs	10	0	10	10	10
Annual Mileage	16,000	12,400	16,000	16,000	16,000
Fuel Economy (MPGGE)	26.7	32.0	37.4	41.4	31.5
Fuel Consumption (GGE/100mi)	3.7	3.1	2.7	2.4	3.2
CD Electricity Use (kWh/100mi)				22.6	33.6
CD Electricity Use (GGE/100mi)				0.7	1.0
CD Gasoline Use (GGE/100mi)				1.4	0.0
PHEV CD Range (miles)				10.9	33.1
Charges/day				1.0	1.0
Days driven/week				7	7
Share of CD miles				25%	76%
Purchase Price ($/vehicle)	$20,000	$22,500	$28,000	$33,000	$35,000
Incentive ($/vehicle)	$0	$0	$0	$0	$0
Maintenance & Repair ($/mile)	$0.14	$0.19	$0.14	$0.13	$0.13

Note: Several fuels to the right of EREV are not shown for clarity in this presentation

AFLEET Tutorial - Simple Payback and TCO Calculators

- View results on "Payback Outputs" sheet



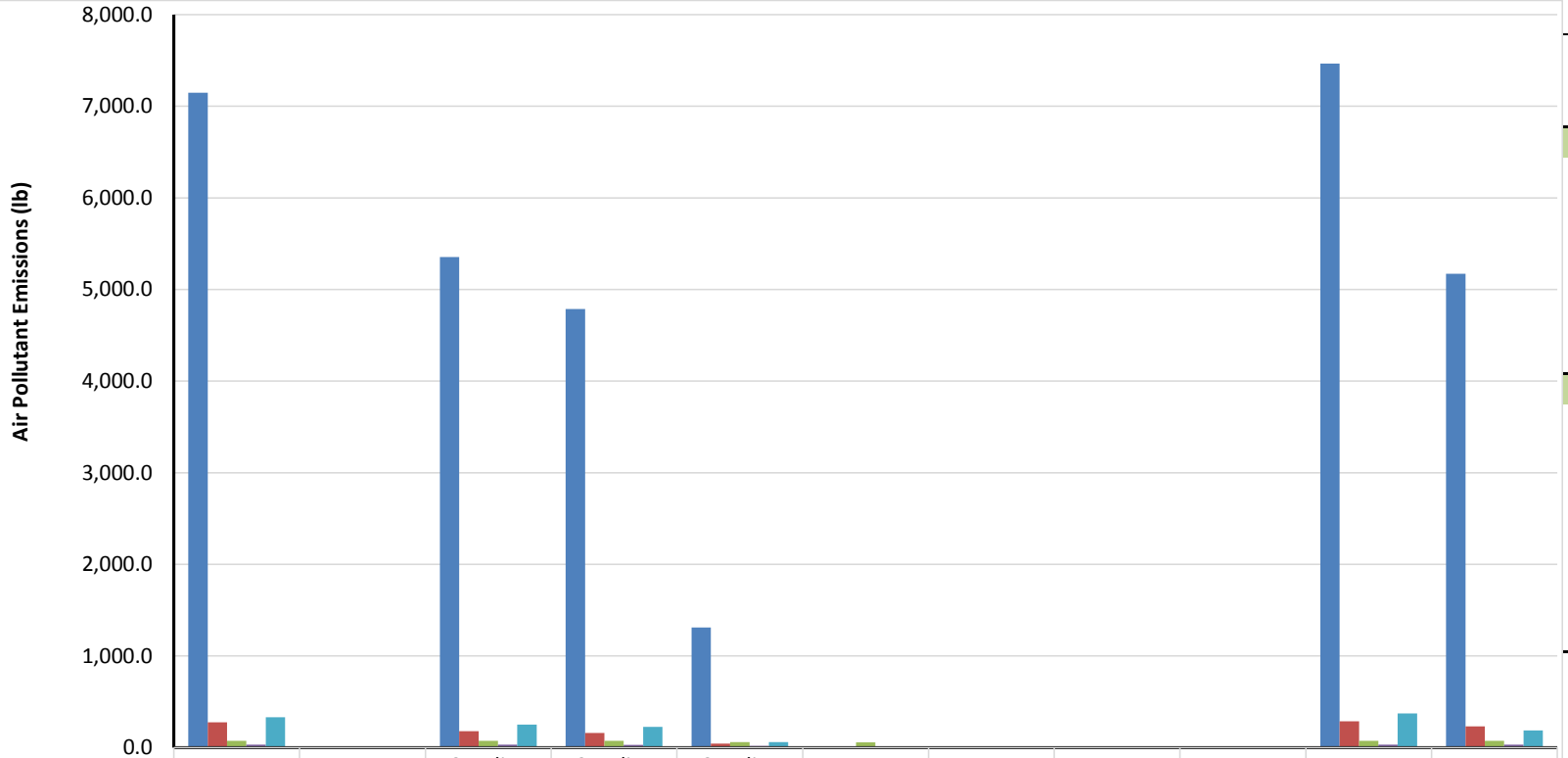
	Gasoline	Diesel	Gasoline HEV	Gasoline PHEV	Gasoline EREV	EV	B20	B100	E85	LPG	CNG
Petroleum Use	125.0		89.3	72.3	26.9	1.3				42.2	0.7
GHG Emissions	72.2		51.6	48.3	44.8	42.6				64.0	62.1

Note: Several fuels are not shown for clarity in this presentation

AFLEET Tutorial - Simple Payback and TCO Calculators

- View results on "TCO Outputs" sheet

	CNG
Light-Duty Pa	
Financing	$25,826
Depreciat	$202,244
Fuel	$96,849
Maintena	$165,947
Insurance	$72,480
License ar	$7,846
Total Cost of	$571,192
Heavy-Duty R	
Financing	$248,692
Depreciat	$2,207,768
Fuel	$4,189,152
Diesel Exh	$0
Maintena	$7,556,352
Insurance	$533,375
License ar	$56,178
Total Cost of	$14,791,515



	Gasoline	Diesel	Gasoline HEV	Gasoline PHEV	Gasoline EREV	EV	B20	B100	E85	LPG	CNG
CO	7,147.0		5,354.1	4,787.1	1,311.5	0.0				7,464.7	5,172.7
NOx	277.3		178.7	159.7	43.8	0.0				287.4	231.8
PM10	75.4		75.4	73.5	61.5	57.0				75.4	75.4
PM2.5	32.3		32.3	30.4	18.6	14.2				32.3	32.3
VOC	332.1		252.3	225.5	61.8	0.0				373.8	187.5

Note: Several fuels are not shown for clarity in this presentation

Using the Fleet Energy & Emissions Footprint Calculator

AFLEET Tutorial - Fleet Energy & Emissions Footprint Calculator

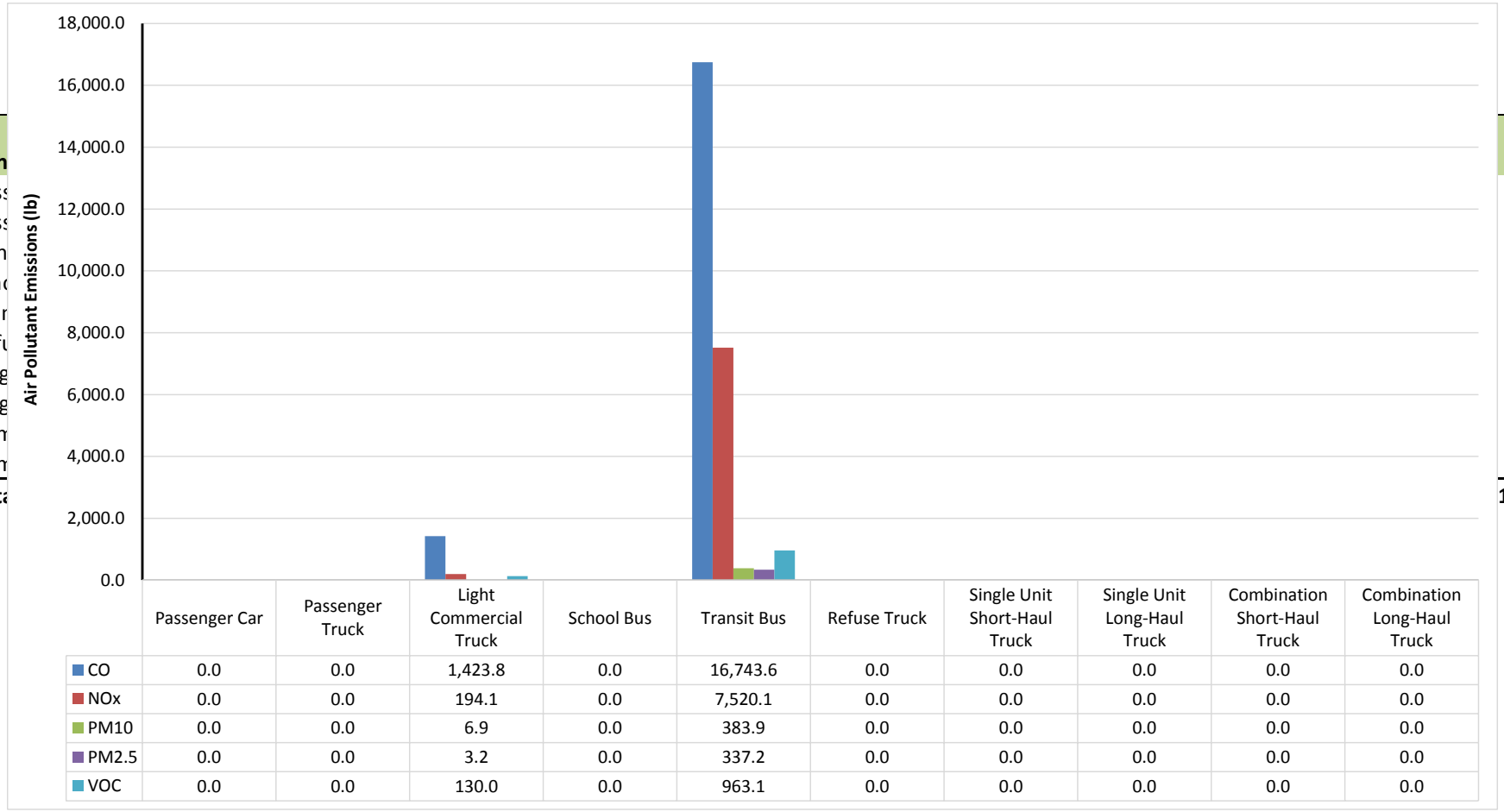
- **Enter inputs on "Footprint" sheet**
  - Vehicle type (via drop-down)
  - Model year
  - Annual mileage
  - Fuel use

Vehicle Type	Model Year	Annual Vehicle Mileage	Fuel Use			Petroleum Use (barrels)	GHG (short tons)	Vehicle Operation Air Pollutant Emissions (lb)							
			Gasoline (gal)	Diesel (gal)	CNG (GGE)			CO	NOx	PM10	PM10 (TBW)	PM2.5	PM2.5 (TBW)	VOC	VOC (Evap)
Light Commercial Truck	1999	8,000	600			12.5	7.2	312.3	46.4	0.5	0.5	0.4	0.1	31.6	1.9
Light Commercial Truck	1999	9,500	700			14.6	8.4	370.8	55.1	0.5	0.6	0.5	0.1	37.5	2.2
Light Commercial Truck	1999	11,000	800			16.7	9.6	429.4	63.9	0.6	0.7	0.6	0.2	43.4	2.6
Light Commercial Truck	2010	12,500	900			18.8	10.8	92.6	8.5	0.2	0.8	0.2	0.2	2.3	0.9
Light Commercial Truck	2010	14,000	1,000			20.9	12.1	103.8	9.6	0.2	0.9	0.2	0.2	2.6	1.0
Light Commercial Truck	2010	15,500	1,100			22.9	13.3	114.9	10.6	0.3	1.0	0.2	0.2	2.8	1.2
Transit Bus	2001	25,000		8,333		213.8	120.9	420.1	854.9	41.8	2.9	40.6	0.7	65.3	0.0
Transit Bus	2001	27,888		9,296		238.5	134.8	468.6	953.7	46.7	3.2	45.3	0.8	72.8	0.0
Transit Bus	2001	28,935		9,645		247.5	139.9	486.2	989.5	48.4	3.3	46.9	0.8	75.5	0.0
Transit Bus	2001	28,980		9,660		247.9	140.1	487.0	991.0	48.5	3.3	47.0	0.8	75.6	0.0
Transit Bus	2001	26,750		8,231		211.2	119.4	449.5	914.7	44.8	3.1	43.4	0.8	69.8	0.0
Transit Bus	2001	27,898		8,584		220.3	124.5	468.8	954.0	46.7	3.2	45.3	0.8	72.8	0.0
Transit Bus	2001	29,500		9,077		232.9	131.6	495.7	1,008.8	49.4	3.4	47.9	0.8	77.0	0.0
Transit Bus	2007	30,150			10,050	1.1	98.9	1,858.1	206.6	1.3	3.5	1.3	0.9	61.2	0.0
Transit Bus	2007	31,407			10,469	1.1	103.1	1,935.6	215.2	1.4	3.6	1.3	0.9	63.7	0.0
Transit Bus	2007	32,664			10,888	1.2	107.2	2,013.1	223.9	1.4	3.7	1.4	0.9	66.3	0.0
Transit Bus	2011	32,150			10,717	1.1	105.5	1,809.1	49.1	1.1	3.7	1.1	0.9	62.1	0.0
Transit Bus	2011	33,407			11,136	1.2	109.6	1,879.9	51.0	1.2	3.8	1.2	1.0	64.6	0.0
Transit Bus	2011	34,664			11,555	1.2	113.8	1,950.6	52.9	1.2	4.0	1.2	1.0	67.0	0.0
Transit Bus	2011	35,921			11,974	1.3	117.9	2,021.3	54.8	1.3	4.1	1.3	1.0	69.4	0.0

Note: Several fuels are not shown for clarity in this presentation

AFLEET Tutorial - Fleet Energy & Emissions Footprint Calculator

- View results on "Footprint Outputs" sheet



	Passenger Car	Passenger Truck	Light Commercial Truck	School Bus	Transit Bus	Refuse Truck	Single Unit Short-Haul Truck	Single Unit Long-Haul Truck	Combination Short-Haul Truck	Combination Long-Haul Truck
CO	0.0	0.0	1,423.8	0.0	16,743.6	0.0	0.0	0.0	0.0	0.0
NOx	0.0	0.0	194.1	0.0	7,520.1	0.0	0.0	0.0	0.0	0.0
PM10	0.0	0.0	6.9	0.0	383.9	0.0	0.0	0.0	0.0	0.0
PM2.5	0.0	0.0	3.2	0.0	337.2	0.0	0.0	0.0	0.0	0.0
VOC	0.0	0.0	130.0	0.0	963.1	0.0	0.0	0.0	0.0	0.0

Veh	VOC (lb)
Pass	0.0
Pass	0.0
Ligh	130.0
Scho	0.0
Tran	963.1
Refu	0.0
Sing	0.0
Sing	0.0
Com	0.0
Com	0.0
Tota	1,093.1

Summary

- **AFLEET can help estimate the economic and environmental costs and benefits of AFVs**
  - Inform new vehicle purchases
  - Examine energy and emissions footprint of existing vehicles
- **Default data provided for key inputs**
  - Using your own makes your analysis more meaningful
- **AFLEET future plans**
  - Include other cost/environmental data as available
    - Infrastructure costs
    - Idle reduction technologies

Thank you!!!

Argonne National Laboratory's work is supported by the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy

This work has been supported and assisted by:

Linda Bluestein: U.S. Department of Energy

Dennis Smith: U.S. Department of Energy

Marcy Rood Werpy: Argonne National Laboratory

For additional information contact:

aburnham@anl.gov