AFLEET TOOL 2020 UPDATES

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Technology Integration Webinar
April 8, 2021

OUTLINE OF PRESENTATION

- **AFLEET Introduction**
- **AFLEET 2020 Updates**
- **AFLEET Demo #1**
  - Off-Road Fleet Footprint Calculator
- **AFLEET Demo #2**
  - Payback Calculator
    - Off-Road Fleet

AFLEET TOOL INTRODUCTION

AFLEET Suite of Tools

AFLEET Spreadsheet

Detailed energy, emission, and cost data for light- and heavy-duty AFVs

AFLEET Online

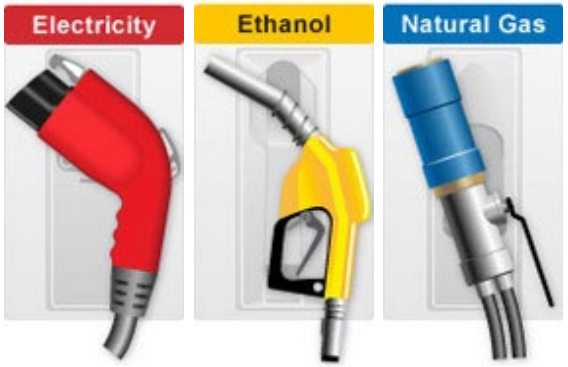
User-friendly interface analyzes petroleum use, emissions, simple payback

Heavy Duty Vehicle Emissions Calculator

Compares NOx, PM, GHGs and cost-effectiveness

AFLEET TOOL 2020

- **Examines light-duty & heavy-duty vehicle:**
  - Petroleum use
  - GHGs
  - Air pollutants
  - Cost of ownership



- **Contains 18 fuel/vehicle technologies**
  - Conventional
  - Hybrids
  - Plug-in electrics
  - Alternative fuels: CNG, LNG, LPG, H_2, ethanol, biodiesel, renewable diesel

- **New in AFLEET 2020**
  - Updated “tailpipe” on-road/off-road emission factors using MOVES3
  - Updated vehicle costs and charging infrastructure
    - Vehicle price, depreciation, maintenance, state insurance, state fees
    - Charger equipment and installation costs for L1, L2, DCFC – 50, 150, 350 kW
  - New off-road payback calculator

- **AFLEET Spreadsheet and Online; HDVEC: afleet-web.es.anl.gov**
  - AFLEET Online and HDVEC updated as well

AFLEET TOOL'S CALCULATION METHODS

1. **Simple Payback Calculator**
   - Annual emissions & simple payback: new AFV vs. conventional
     - On-road vehicles
     - Off-road equipment

2. **Total Cost of Ownership Calculator**
   - Lifetime emissions & NPV of costs: new AFV vs. conventional

3. **Idle Reduction Calculator**
   - Annual emissions & simple payback: IR equipment vs. idling

4. **On-Road Fleet Footprint Calculator**
   - Annual & remaining lifetime emissions of existing & new vehicles

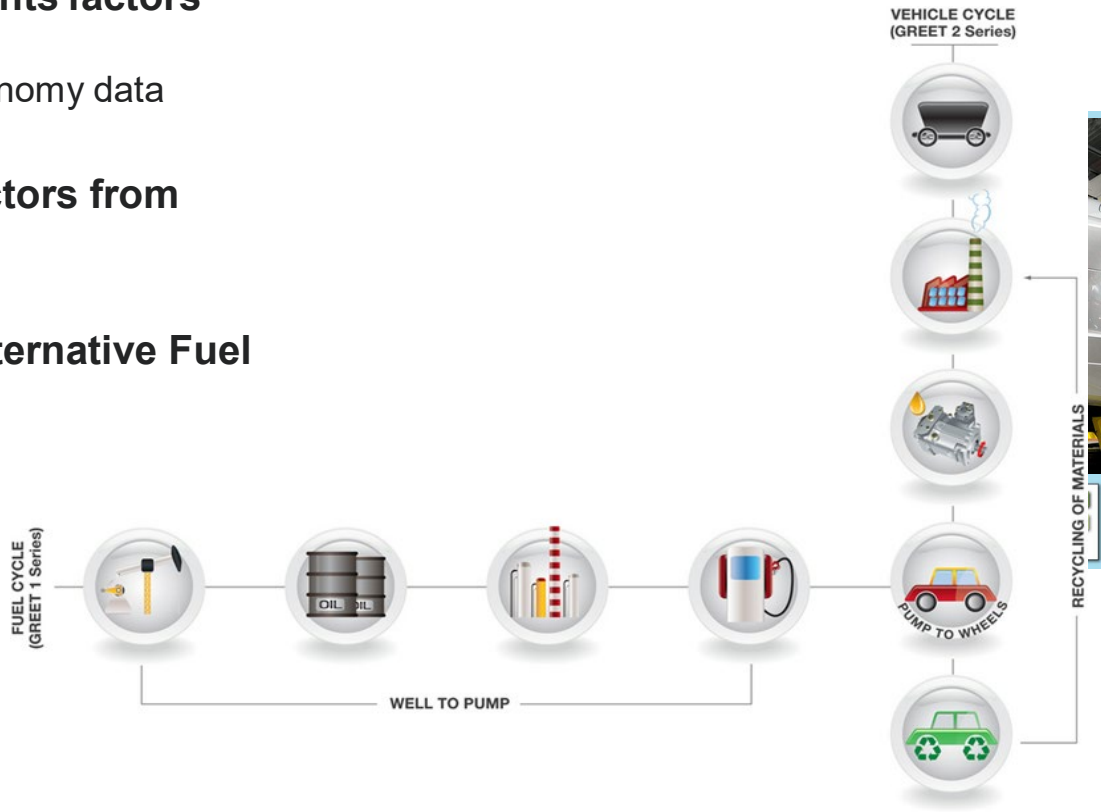
5. **Off-Road Fleet Footprint Calculator**
   - Annual & remaining lifetime emissions of existing & new off-road equipment

6. **EV Charging Calculator**
   - Annual emissions benefit of utilizing public charging infrastructure

*red text = new feature

KEY DATA SOURCES

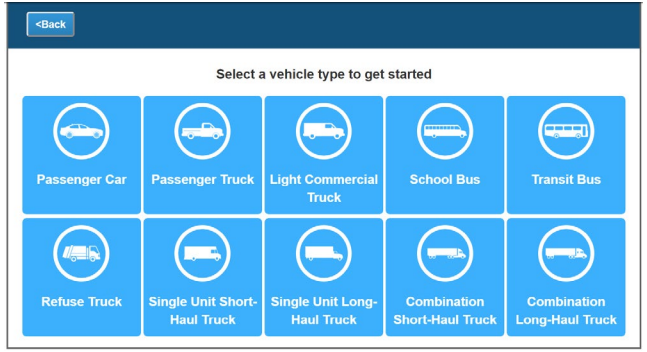
- **Petroleum use, GHGs, air pollutants factors from Argonne's GREET 1 2020**
  - Light-duty and heavy-duty fuel economy data
- **Vehicle air pollutant emission factors from EPA's MOVES3**
- **Fuel prices using Clean Cities Alternative Fuel Price Reports**

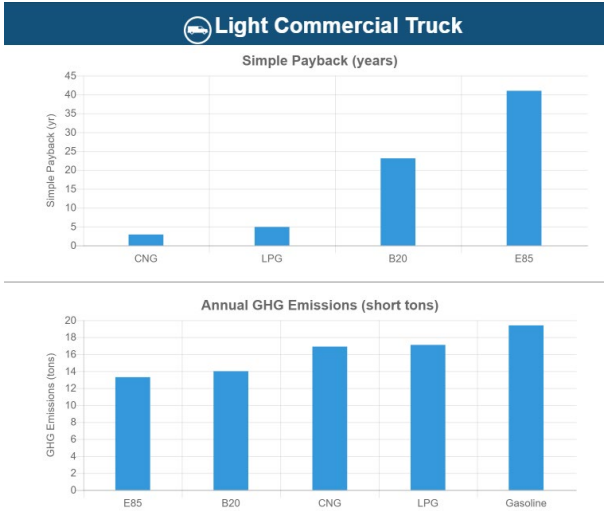


Argonne NATIONAL LABORATORY

AFLEET ONLINE

- **User friendly, web-based version**
  - Replicates Simple Payback Calculator
- **Examines light-duty & heavy-duty vehicle:**
  - Petroleum use
  - GHG emissions
  - Air pollutant emissions
  - Simple payback
- **Contains 18 fuel/vehicle technologies**
  - Conventional: 2
  - Hybrids: 3
  - Plug-in electrics: 3
  - Alternative fuels: 10
- **AFLEET Online: afleet-web.es.anl.gov/afleet/**





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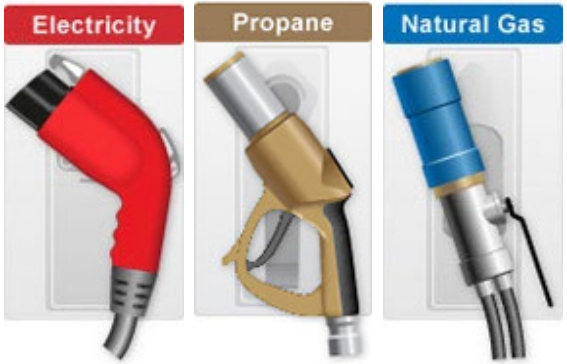
HEAVY-DUTY VEHICLE EMISSIONS CALCULATOR

- **Simple online tool based on AFLEET to help analyze AFVs for funding opportunities**
- **Examines medium-duty & heavy-duty vehicle:**
  - Vehicle operation NO_x & $PM_{2.5}$
  - WTW GHGs
  - Emission reduction cost effectiveness
- **Contains 4 fuel/vehicle technologies:**
  - Diesel
  - Electric vehicle
  - Propane
  - Natural gas
- **HDVEC available at:** afleet-web.es.anl.gov/hdv-emissions-calculator/

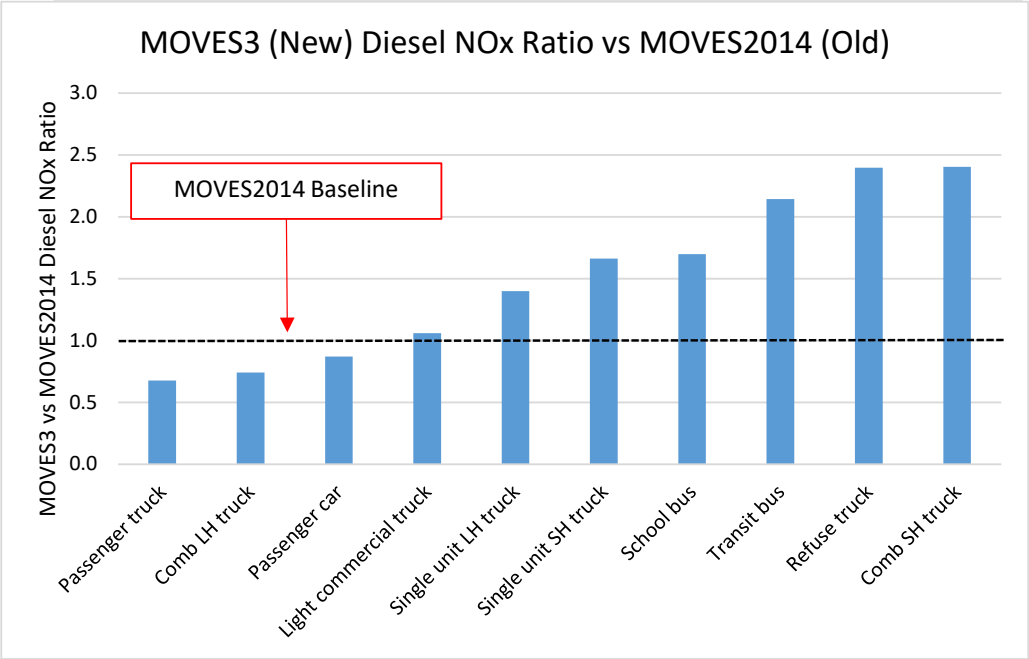


AFLEET TOOL 2020 UPDATES

AFLEET TOOL 2020 – DIESEL IN-USE & LOW-NO_X EMISSIONS

- **Diesel in-use NOx feature**
  - EPA MOVES3 updated diesel NOx for HDVs but not LDVs
  - EPA DEQ current version (8.4) does not have MOVES3 data
  - AFLEET optional setting

- **Heavy-duty low-NOx feature**
  - Includes CNG, LNG, and LPG low-NOx HDVs
  - AFLEET default setting



- **AFLEET 2019 multipliers:**
  - **5x LDV,**
  - **4x HDV except 1.5x Comb LH/SH, SU LH**

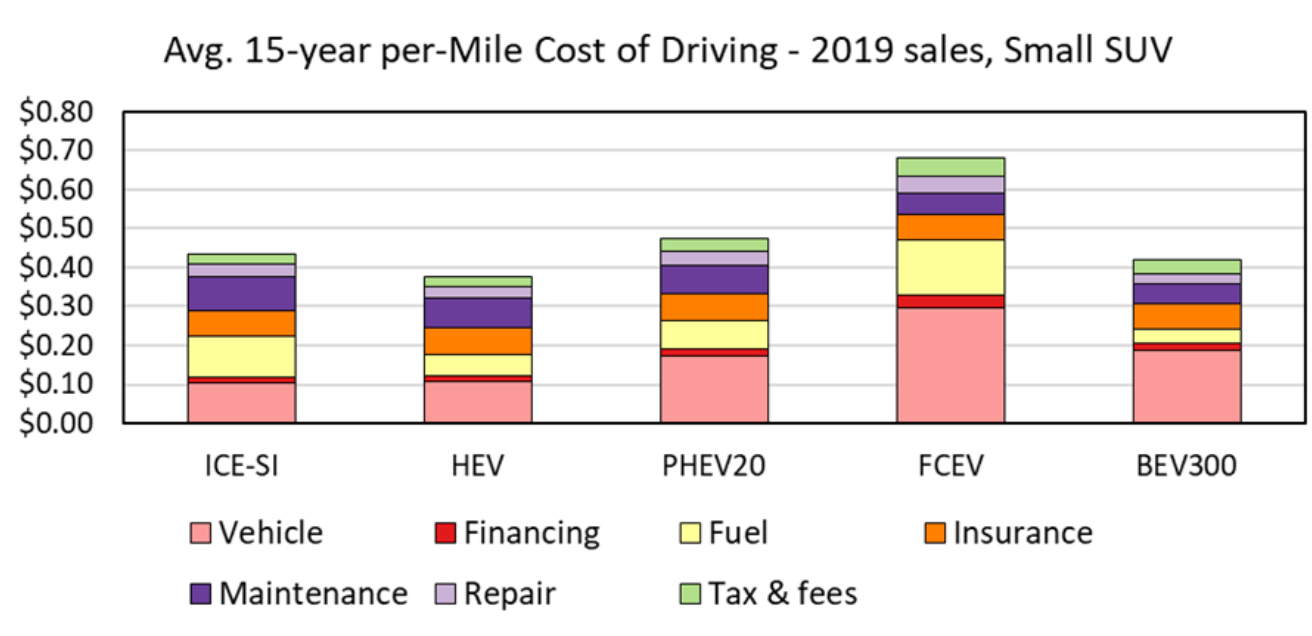
Anenberg, 2017, Impacts and mitigation of excess diesel-related NOx emissions in 11 major vehicle markets

Cai, 2017, Wells to Wheels: Environmental Implications of Natural Gas As A Transportation Fuel

Sandhu, 2017, In-Use Emission Rates for MY 2010+ Heavy-Duty Diesel Vehicles

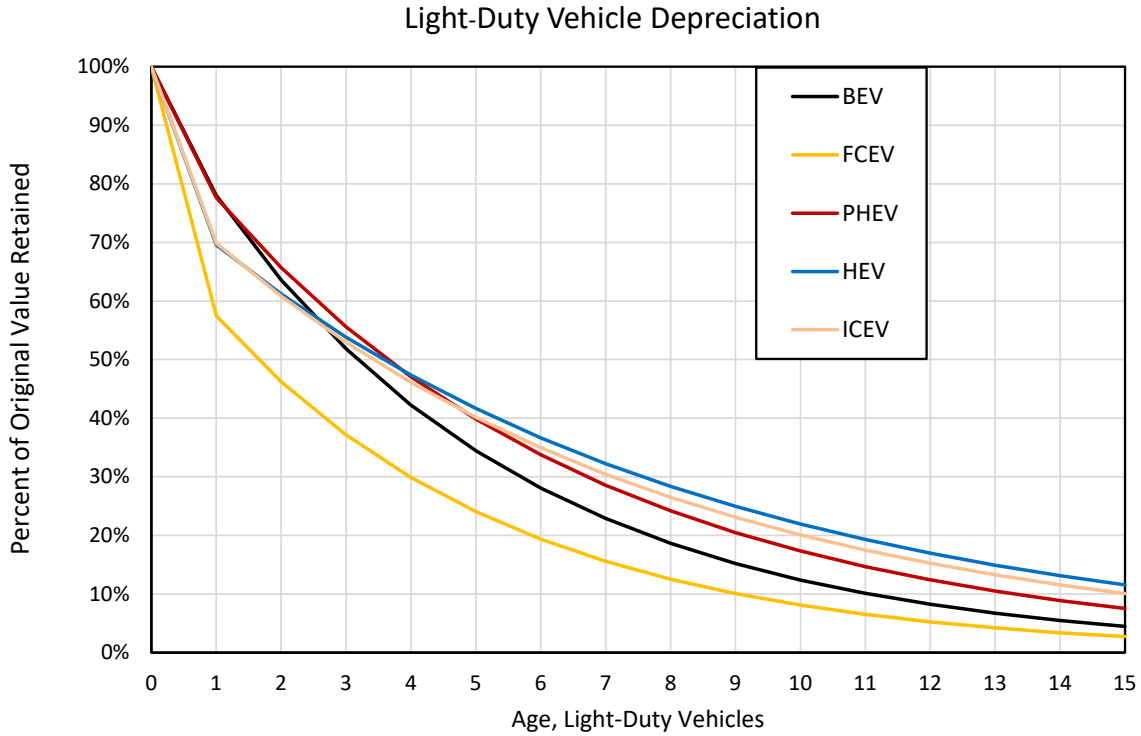
Ryskamp, 2020, Chassis Dynamometer Evaluation of Propane Powered MD to HD Vehicles

MY2019 HEV AND BEV300 HAVE LOWER 15 YR TCO THAN ICEV (W/ NO INCENTIVES)



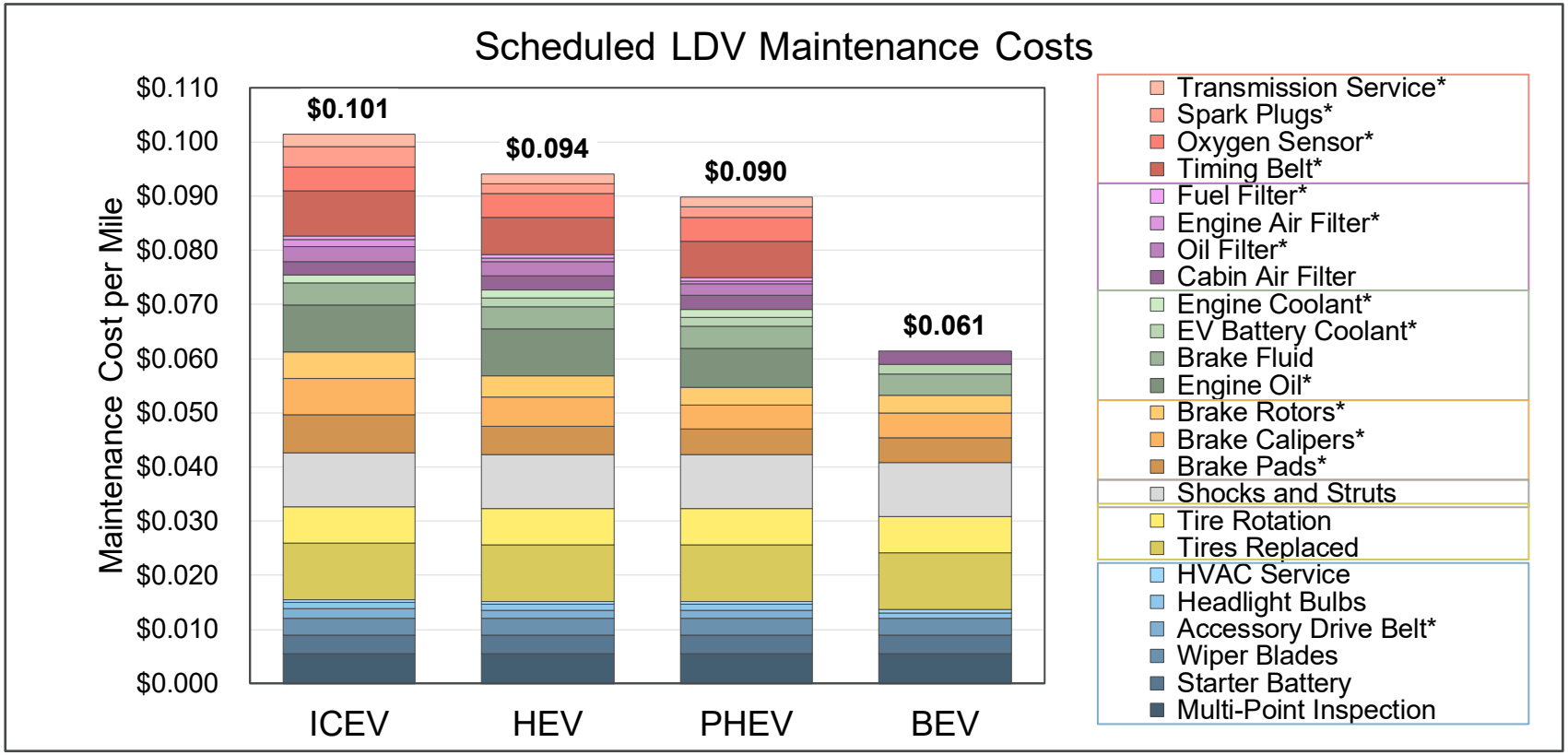
Burnham et al. Forthcoming, Comprehensive Total Cost of Ownership Quantification for Vehicles with Different Size Classes and Powertrains

OLDER PEVS TYPICALLY DEPRECIATE FASTER THAN ICEVS, BUT MY2017+ PEVS ARE RETAINING VALUE THAN ICEV



Burnham et al. Forthcoming, Comprehensive Total Cost of Ownership Quantification for Vehicles with Different Size Classes and Powertrains

LDV: MAINTENANCE & REPAIR NEARLY 40% LOWER FOR BEV



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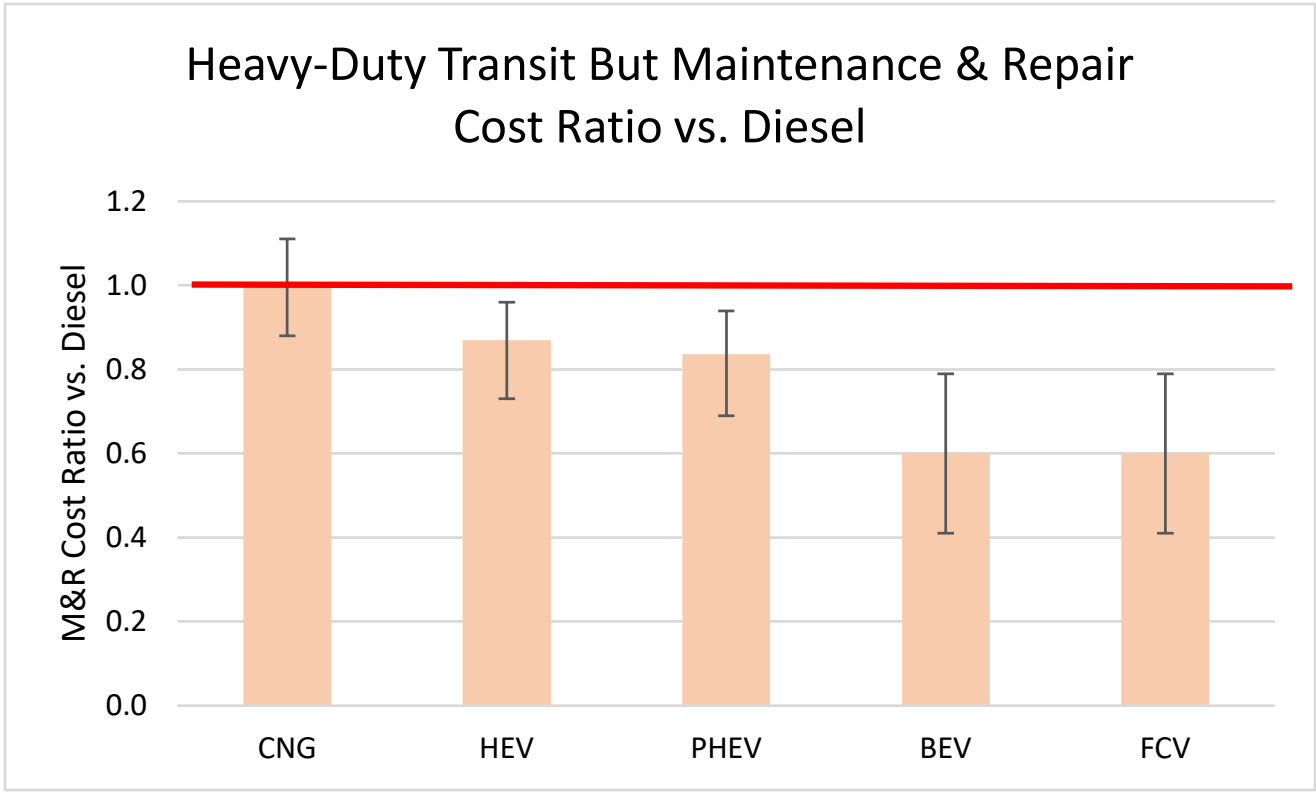
HDV: MAINTENANCE & REPAIR NEARLY 40% LOWER FOR BEV



Burnham et al. Forthcoming, Comprehensive Total Cost of Ownership Quantification for Vehicles with Different Size Classes and Powertrains

Using the Fleet Footprint Calculator to Examine Existing Off-Road Equipment

AFLEET TUTORIAL – OFF-ROAD FLEET FOOTPRINT CALCULATOR

- **1st step: enter location on "Inputs" sheet**

Primary Vehicle Location	
State	CALIFORNIA
County	LOS ANGELES

- **2nd step: adjust fuel production & energy/emission assumptions on "Inputs" sheet**

Fuel Production Assumptions

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

Petroleum Use, GHGs & Air Pollutant Options

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

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

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AFLEET TUTORIAL – OFF-ROAD FLEET FOOTPRINT CALCULATOR

- **4th step: copy and paste fleet data into "Off-Road Footprint" sheet**
  - Model year
  - Annual hourly usage
  - Rated horsepower
  - Fuel use
- **5th step: adjust equipment type via drop-down**

Equipment Type	Model Year	Annual Usage (hours)	Rated Horsepower (hp)	Fuel Use							Remaining Lifetime (hours)			
				Gasoline (gal)	Diesel (gal)	Electricity (kWh)	G.H2 (kg)	B20 (gal)	B100 (gal)	RD20 (gal)	dian Life Full Load	Calculated Lifetime	Cumulative Hours	Remaining Lifetime
Aerial Lifts	2005	361	41	154							3,000	6,522	5,415	1,107
Aerial Lifts	2005	361	41	154		1,269					3,000	6,522	5,054	1,468
Agricultural Tractors	2005	55	65	50							3,000	4,839	770	4,069
Agricultural Tractors	2005	55	65	50							3,000	4,839	770	4,069
Airport Support Equipment	2005	681	43	372							3,000	5,357	1,400	3,957
Airport Support Equipment	2005	681	43	372							3,000	5,357	2,100	3,257
All Terrain Vehicles	2005	3,216	2	146							3,000	3,000	1,400	1,600
All Terrain Vehicles	2005	3,216	2	146							3,000	3,000	1,400	1,600
Chain Saws	2005	33	3	2							400	571	462	109
Chain Saws	2005	33	3	2							400	571	462	109
Commercial Turf Equipment	2005	1,364	25	464							3,000	5,000	1,400	3,600
Commercial Turf Equipment	2005	1,364	25	464							3,000	5,000	1,400	3,600
Cranes	2005	99	365		500						4,667	10,853	1,386	9,467
Cranes	2005	99	365		500						4,667	10,853	1,386	9,467

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

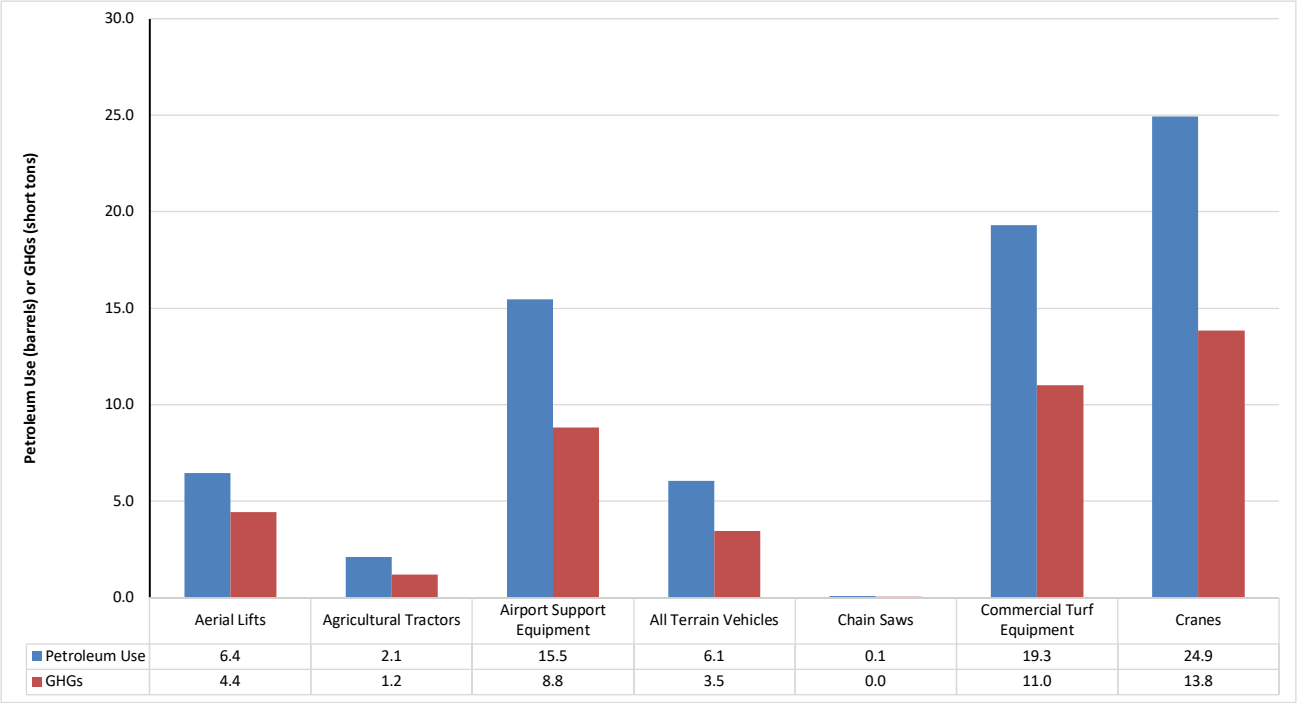
AFLEET TUTORIAL – OFF-ROAD FLEET FOOTPRINT CALCULATOR

- **View existing fleet results on "Footprint Outputs" sheet**

Vehicle Type	Petroleum Use (barrels)	GHGs (short tons)	CO (lb)	NOx (lb)	PM10 (lb)	PM2.5 (lb)	VOC (lb)	SOx (lb)
Aerial Lifts	6.4	4.4	749.0	58.4	1.1	1.0	17.7	0.0
Agricultural Tractors	2.1	1.2	516.4	36.6	0.7	0.7	12.1	0.0
Airport Support Equipment	15.5	8.8	3,772.1	290.1	5.5	5.1	91.2	0.1
All Terrain Vehicles	6.1	3.5	1,402.8	7.1	71.5	65.8	1,860.0	0.0
Chain Saws	0.1	0.0	81.3	0.5	3.0	2.7	18.8	0.0
Commercial Turf Equipment	19.3	11.0	4,755.0	342.4	6.9	6.3	112.3	0.1
Cranes	24.9	13.8	56.9	430.6	12.7	12.3	22.7	0.2
Crawler Tractor/Dozers	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
Forklifts	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
Lawn & Garden Tractors	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lawn Mowers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Leafblowers/Vacuums	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rollers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rubber Tire Loaders	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Skid Steer Loaders	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Snowblowers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sweepers/Scrubbers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Terminal Tractors	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tractors/Loaders/Backhoes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Trimmers/Edgers/Brush Cutter	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	**74.4**	**42.8**	**11,333.5**	**1,165.7**	**101.4**	**93.9**	**2,134.9**	**0.4**

AFLEET TUTORIAL – OFF-ROAD FLEET FOOTPRINT CALCULATOR

- View existing fleet results on “Footprint Outputs” sheet



	Aerial Lifts	Agricultural Tractors	Airport Support Equipment	All Terrain Vehicles	Chain Saws	Commercial Turf Equipment	Cranes
Petroleum Use	6.4	2.1	15.5	6.1	0.1	19.3	24.9
GHGs	4.4	1.2	8.8	3.5	0.0	11.0	13.8

Using Simple Payback to Compare Potential Off-Road Acquisitions

AFLEET TUTORIAL – SIMPLE PAYBACK CALCULATOR: OFF-ROAD

- **1st step: enter location on "Inputs" sheet**

Primary Vehicle Location	
State	CALIFORNIA
County	LOS ANGELES

- **2nd step: enter fuel price inputs on "Inputs" sheet**
  - Choose either public or private station fuel pricing (via drop-down)
  - Choose if you want to look at fuel price sensitivity for simple payback (via drop-down)
  - Enter fuel price data (in respective fuel unit)

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

AFLEET TUTORIAL – SIMPLE PAYBACK CALCULATOR: OFF-ROAD

- 3rd step: adjust fuel production & energy/emission assumptions on “Inputs” sheet

Fuel Production Assumptions

Biodiesel Feedstock Source	1 - Soy	1	
	2 - Canola		
	3 - Corn		
	4 - Tallow		
Ethanol Feedstock Source	1 - Corn	1	
	2 - Switchgrass		
	3 - Sugarcane		
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CNG Feedstock Source	1 - North American NG	1	
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North American NG Feedstock Source		Conventional	Shale
		66%	34%
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Source of Electricity for PHEVs, EVs, and FCVs (Electrolysis)		7	
	1 - Average U.S. Mix		
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	12 - User Defined (go to 'Background Data' sheet)		
G.H2 Production Process	1 - Refueling Station SMR (On-site)	1	
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Petroleum Use, GHGs & Air Pollutant Options

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1 - WTW Petroleum Use and GHGs & Tailpipe Air Pollutants		
2 - WTW Petroleum Use, GHGs, and Air Pollutants		
3 - WTW & Vehicle Production* Petroleum Use, GHGs, Air Pollutants (*LDVs only)		
Diesel In-Use Emissions Multiplier	yes/no	No
Low NOx Engines - CNG and LNG HDVs	yes/no	Yes

AFLEET TUTORIAL – SIMPLE PAYBACK CALCULATOR: OFF-ROAD

- **4th step: enter key inputs on "Inputs" sheet**
  - Equipment type, rated horsepower, EV battery replacement assumptions
  - # of equipment, hourly usage, fuel consumption, purchase price, and maintenance costs
  - Can simulate both small equipment and large equipment

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) Fuel Cell Vehicle (FCV)	0	1,700	0.23	$40,000	$0.08
Diesel Hybrid Electric Vehicle (HEV)	0	0	0.48	$0	$0.00
Diesel Hydraulic Hybrid (HHV)	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 (CNG)	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

AFLEET TUTORIAL – SIMPLE PAYBACK CALCULATOR: OFF-ROAD

- **5th step: if examining fuel price sensitivity, enter additional data on "Payback" sheet**
  - Enter high and low fuel prices for either public or private station
    - Can either enter values or % relative to default price
    - Do not have to enter multiple times for vehicles using same fuel

	Gasoline	Diesel	Gasoline HEV	Gasoline PHEV	Gasoline EREV	EV	G.H2 FCV
Fuel Price Sensitivity							
Public Fuel Price Sensitivity Case	No						
High Fuel Price (% increase vs default)	17%	19%	17%	17%	17%	0%	0%
High Primary Fuel Price ($/GGE)	$3.51	$3.13	$3.51	$3.51	$3.51	$5.34	$20.29
High Secondary Fuel Price ($/GGE)				$5.34	$5.34		
Low Primary Fuel Price (% decrease vs default)	17%	19%	17%	17%	17%	0%	0%
Low Primary Fuel Price ($/GGE)	$2.51	$2.13	$2.51	$2.51	$2.51	$5.34	$20.29
Low Secondary Fuel Price ($/GGE)				$5.34	$5.34		
Private Fuel Price Sensitivity Case	No						
High Fuel Price (% increase vs default)	18%	19%	17%	17%	17%	0%	0%
High Primary Fuel Price ($/GGE)	$3.34	$3.13	$3.31	$3.31	$3.31	$5.34	$6.99
High Secondary Fuel Price ($/GGE)				$5.34	$5.34		
Low Primary Fuel Price (% decrease vs default)	18%	19%	17%	17%	17%	0%	0%
Low Primary Fuel Price ($/GGE)	$2.34	$2.13	$2.37	$2.37	$2.37	$5.34	$6.99
Low Secondary Fuel Price ($/GGE)				$5.34	$5.34		

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

AFLEET TUTORIAL – SIMPLE PAYBACK CALCULATOR: OFF-ROAD

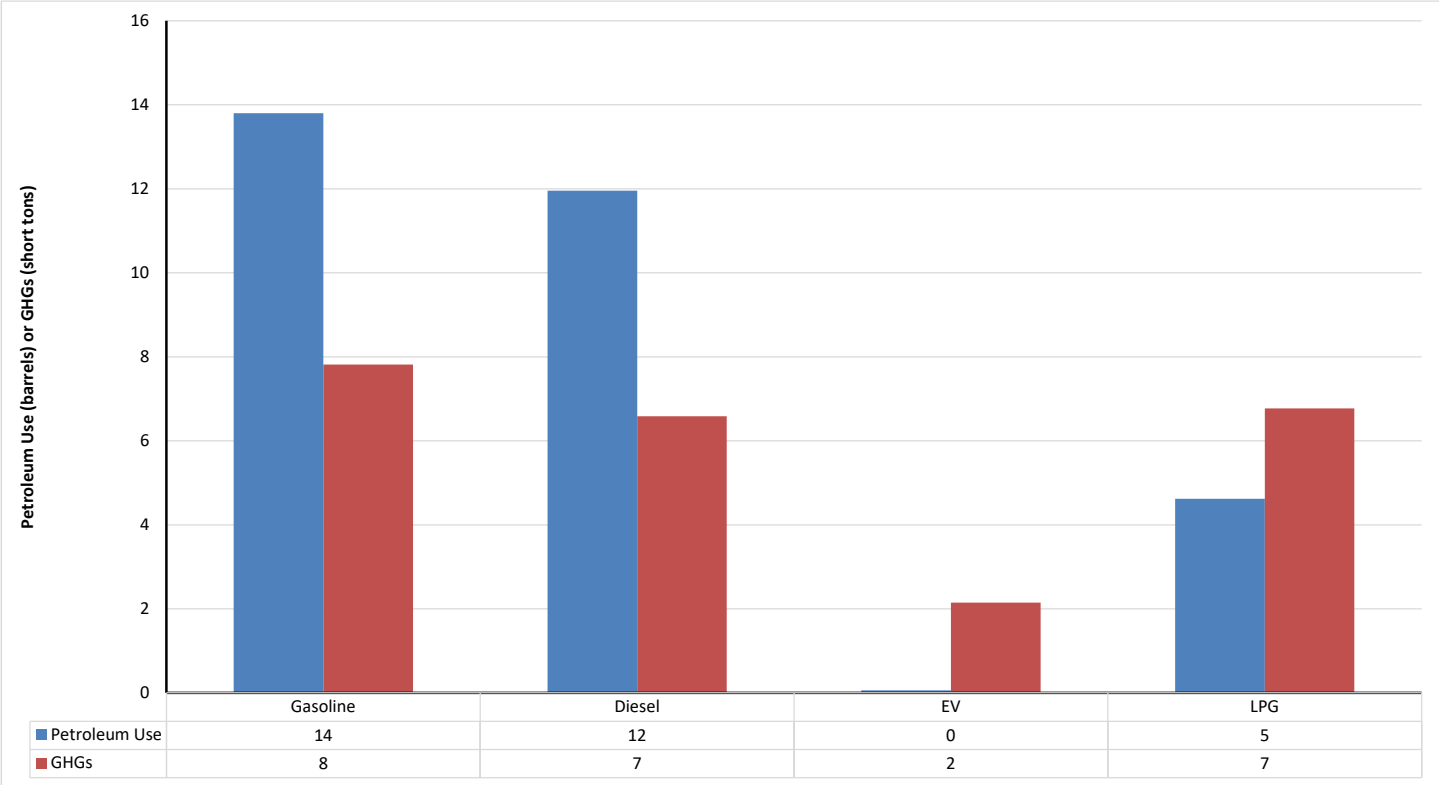
- **6th step: if examining infrastructure costs, enter additional data on "Payback" sheet**
  - Enter station type (via drop down), number of stations, and station & O&M costs

	Gasoline	Diesel	Gasoline HEV	Gasoline PHEV	Gasoline EREV	EV
Infrastructure Inputs						
Station/EVSE Type	New Private	New Private	New Private	Level 2 - Parking Garage	Level 2 - Parking Garage	Level 2 - Parking Garage
Number of stations/EVSEs	0	0	0	13	13	13
Total Refueling Station/EVSE Cost	$0	$0	$0	$40,556	$40,556	$40,556
Total Incentive	$0	$0	$0	$0	$0	$0
Maintenance Depot Cost	$0	$0	$0	$0	$0	$0
Annual Private Station/EVSE Operation & Mainter	$0	$0	$0	$9,100	$9,100	$9,100
Default Refueling Station/EVSE Cost	$0	$0	$0	$40,556	$40,556	$40,556
Default Annual Private Station/EVSE O&M Costs ($	$0	$0	$0	$9,100	$9,100	$9,100
Annual Private Fueling Labor & Misc. Costs ($/yr)	$0	$0	$0	$0	$0	$0

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

AFLEET TUTORIAL – SIMPLE PAYBACK CALCULATOR: OFF-ROAD

- View results on “Payback-Offroad Output” sheet



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

Argonne NATIONAL LABORATORY

THANK YOU!!!

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