

AFLEET TOOL 2019 UPDATES

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Technology Integration Webinar

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OUTLINE OF PRESENTATION

- **AFLEET 2019 Updates**

- EV Charging Calculator
- Off-Road Footprint Calculator
- Propane Low-NOx Emissions

- **AFLEET Demo #1**

- EV Charging Calculator

- **AFLEET Demo #2**

- Off-Road Fleet Footprint Calculator

AFLEET TOOL 2019 UPDATES



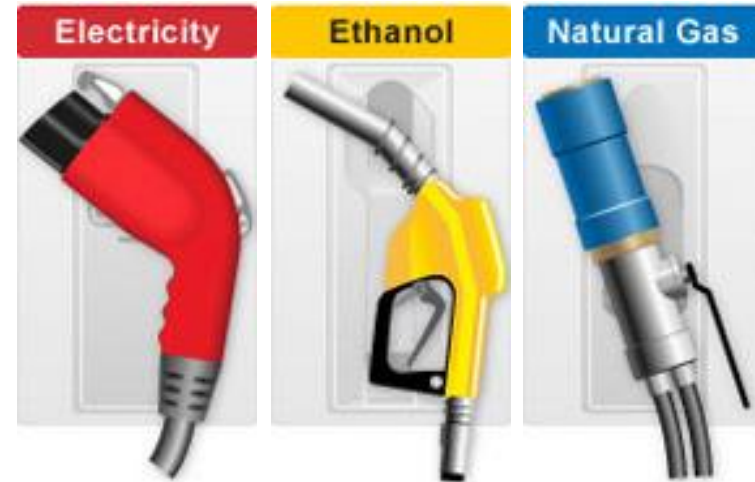
“AFLEET TOOL” TO ANALYZE AFV COSTS & BENEFITS

- **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, H2, ethanol, biodiesel, renewable diesel



- **New features in AFLEET 2019 Spreadsheet**

- Public EV Charging and Off-Road Footprint calculators
- Low-NOx LPG engines
- Maintenance cost updates

- **AFLEET 2019 Spreadsheet available at: greet.es.anl.gov/afleet**

AFLEET TOOL'S CALCULATION METHODS

1. Simple Payback Calculator

- Annual emissions & simple payback: new AFV vs. conventional

2. Total Cost of Ownership Calculator

- Lifetime emissions & NPV of costs: new vehicle

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

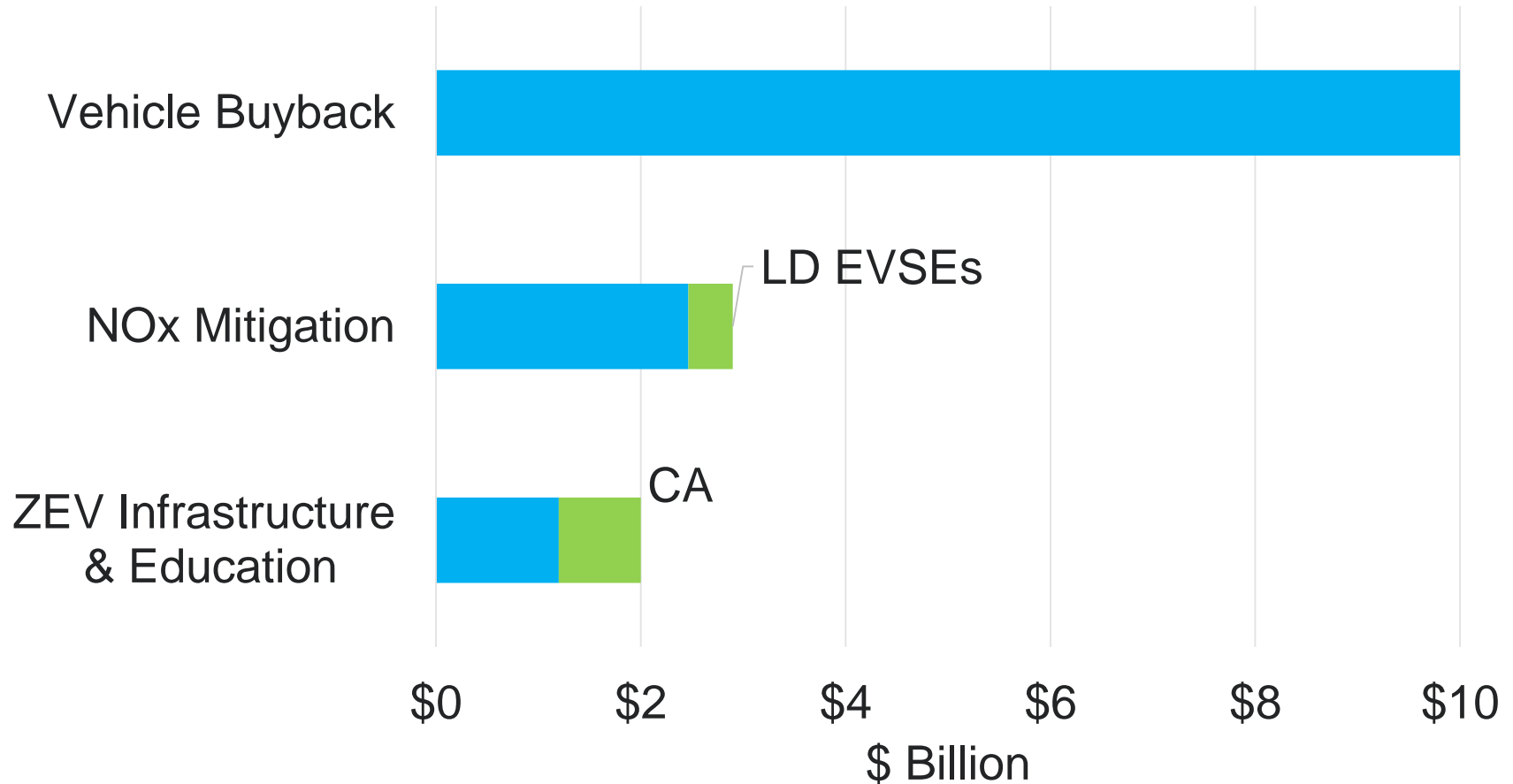


EV CHARGING CALCULATOR



VW SETTLEMENT = \$2+ BILLION FOR EV CHARGING

VW Settlement Breakdown



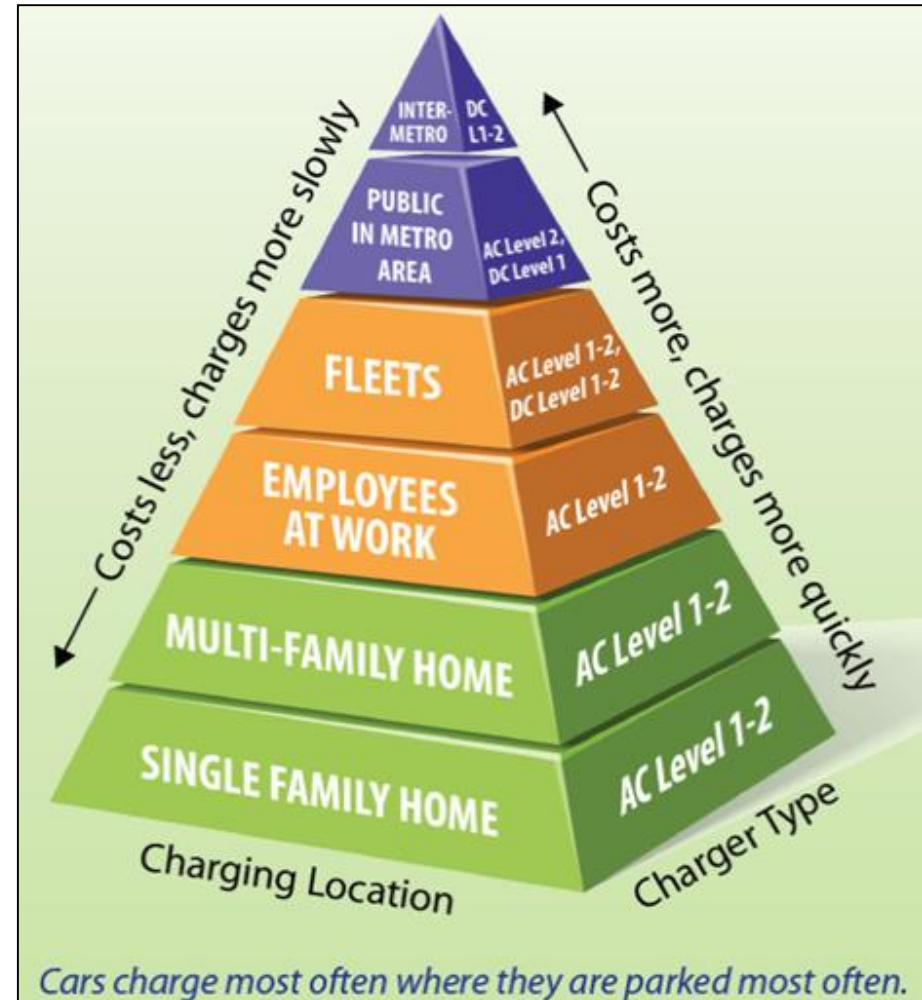
UTILITIES MAKING LARGE CHARGING INVESTMENTS

Public Utility Filings 2012 – June 2019

Approved	Pending/Filed
21	21
States	States
61	31
Filings	Filings
39	25
Utilities	Utilities
\$1,152,227,741	\$1,579,700,976
Investment	Investment
1,996	1,048
DC Fast Charging Stations	DC Fast Charging Stations
45,112	125,740
Level 2 Charging Stations	Level 2 Charging Stations

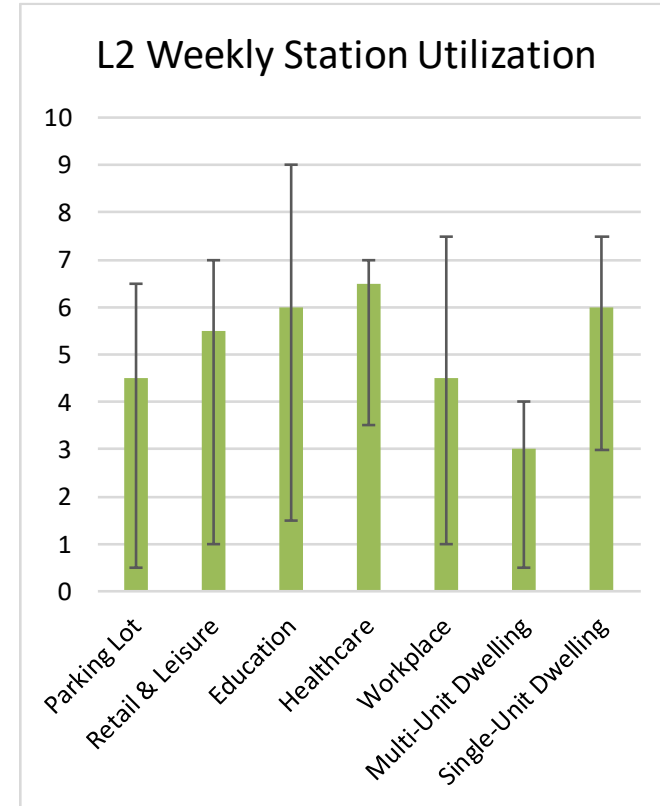
OVERVIEW OF PUBLIC CHARGING DEPLOYMENT

- **70 public chargers per 1000 PEVs (L2/DCFC) in 2017**
 - L2: 15,000 (2017) -> ~26,000 (2019)
 - DCFC: 2,000 (2017) -> ~4,000 (2019)
- **Areas w/ highest EV market penetration in 2017:**
 - Less chargers than national average
 - 47 L2 /1000 PEVs
 - 4 DCFCs/1000 EVs
- **Few studies have analyzed optimal ratio of chargers per PEV**
 - NREL for 15 million PEVs in 2030
 - ~36 - 79 L2 /1000 PEVs
 - ~1.5 - 3 DCFC stations/1000 PEVs



EV CHARGING CALCULATOR INTRODUCTION

- **What are emissions/energy benefits of EV public charging infrastructure?**
- **Methodology:**
 1. Utilization, kW & charge time
 - L2 vs DC Fast
 - Parking lot, retail/leisure, education, healthcare, workplace, multi-unit dwelling
 - Single-unit dwelling included for comparison
 2. Electricity dispensed by charger
 3. EV miles based on electricity dispensed & weighted EV efficiency
 4. Emissions from EV miles
 5. Emissions from gasoline miles being displaced
 6. Benefit = gasoline emissions - EV emissions

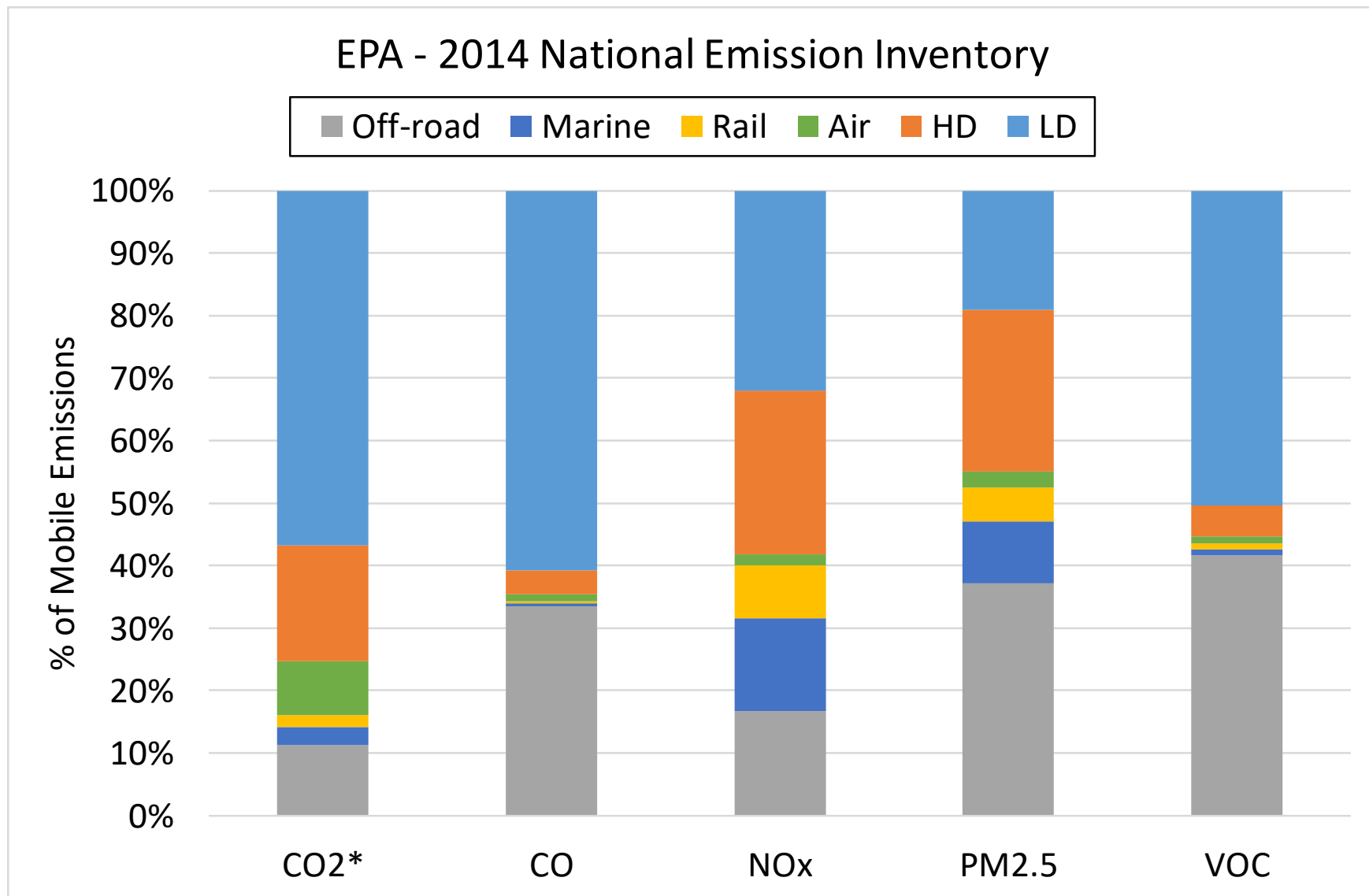


- **Relationship between increasing public charging & EV adoption**
 - Literature is inconclusive
 - Increasing availability acts as incentive, but it is not enough to spur adoption

OFF-ROAD FOOTPRINT CALCULATOR



OFF-ROAD = LARGE SOURCE OF MOBILE AIR POLLUTION



*CO2 from Marine, Rail, Air based on EPA 2019 GHG Inventory

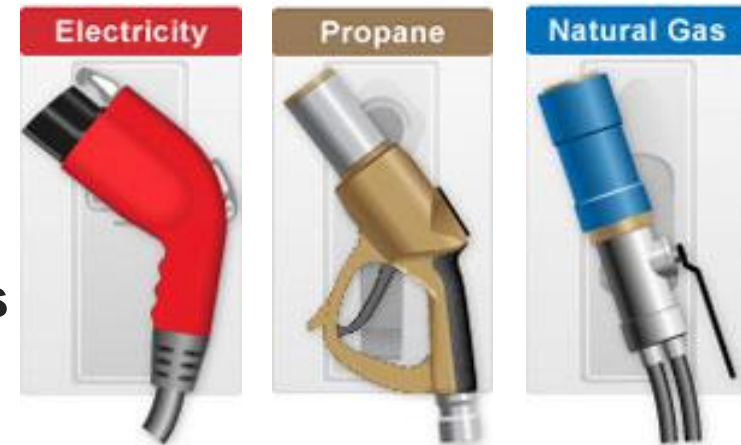
OFF-ROAD FOOTPRINT CALCULATOR INTRODUCTION

- **Examines off-road equipment:**

- Petroleum use
- GHGs
- Air pollutants

- **Contains 12 fuel/equipment technologies**

- Conventional
- Electric
- Alternative fuels: CNG, LNG, LPG, H₂, ethanol, biodiesel, renewable diesel



- **Includes 22 equipment types (in 6 EPA NONROAD categories)**

- Data based on EPA MOVES2014b
 - Emission factors: conventional and alt. fuel
 - Annual usage
 - Rated horsepower
 - Equipment lifetime

- **Feedback on equipment types & data appreciated**

- Spoken to coordinators about marine and rail

AFLEET OFF-ROAD EQUIPMENT CATEGORIES & TYPES

1. Agricultural

- Agricultural tractors

2. Airport support

- Airport support equipment

3. Construction

- Cranes
- Crawler tractor/dozers
- Excavators
- Rollers
- Rubber tire loaders
- Skid steer loaders
- Tractors/loaders/backhoes

4. Industrial

- Aerial lifts
- Forklifts
- Sweepers/scrubbers
- Terminal tractors

5. Lawn & garden

- Chain saws
- Commercial turf equipment
- Lawn & garden tractors
- Lawn mowers
- Leafblowers/vacuums
- Snowblowers
- Trimmers/edgers/brush cutter

6. Recreational

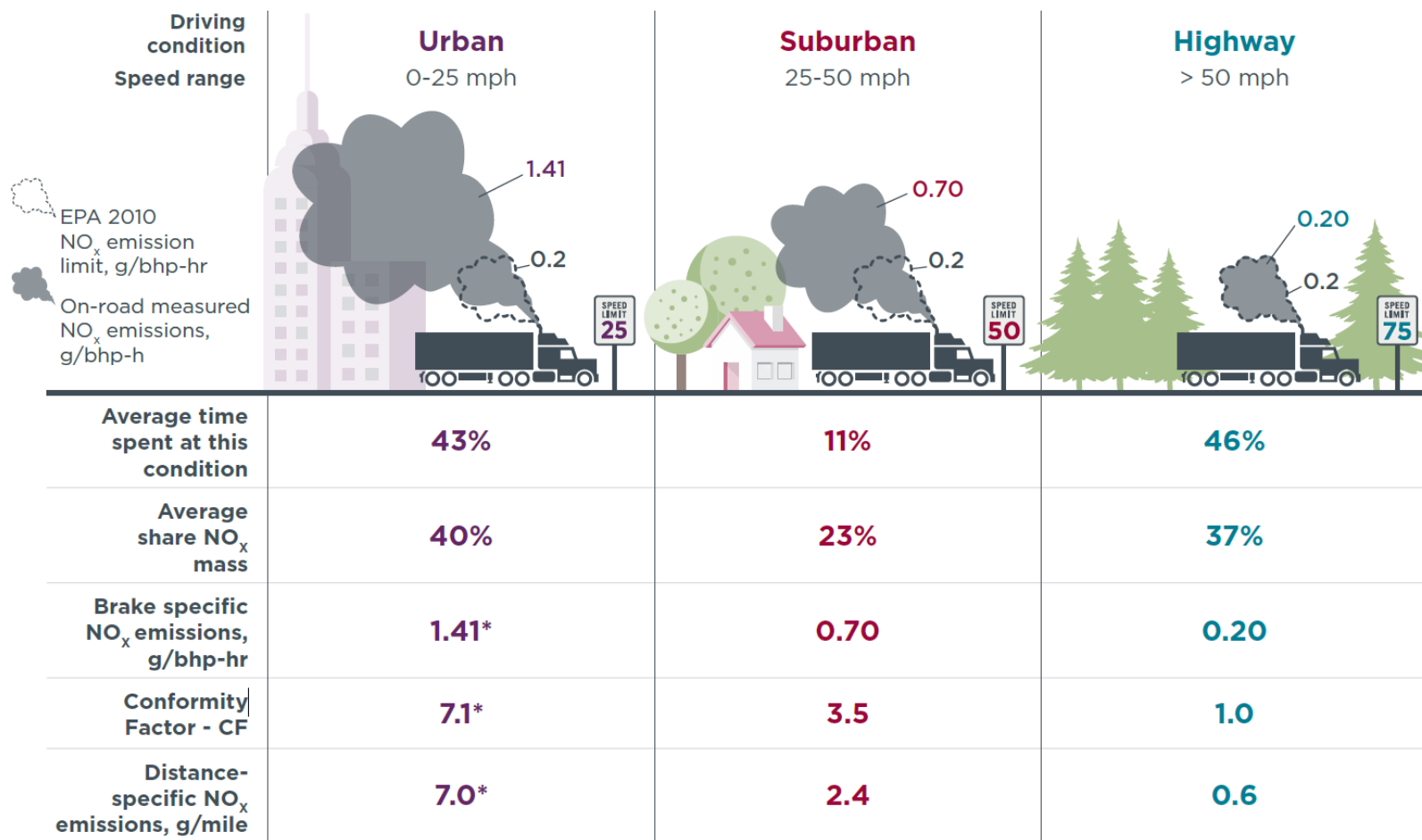
- All terrain vehicles
- Golf carts



PROPANE LOW-NO_x EMISSIONS

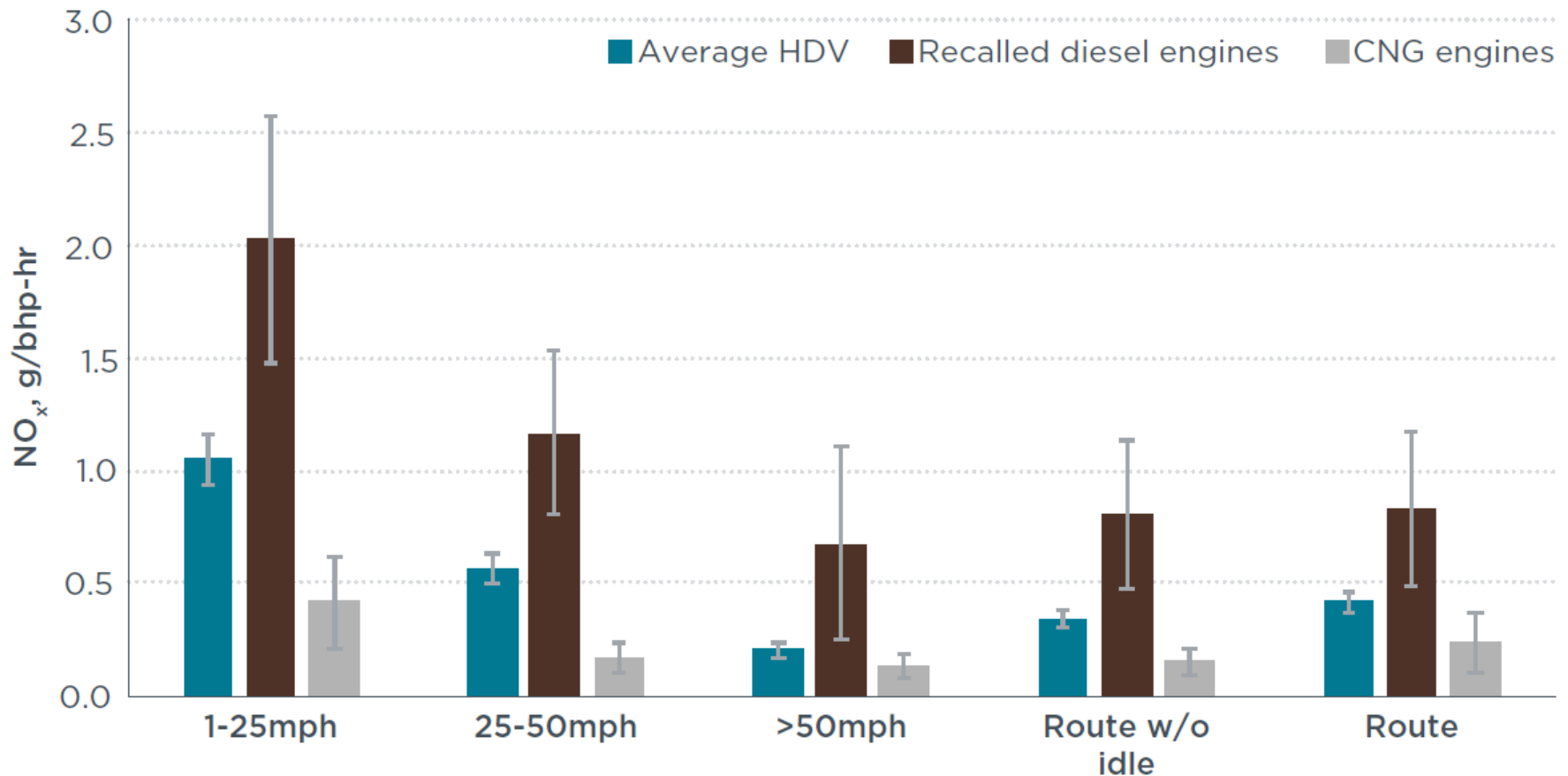


IN-USE DIESEL NO_x MUCH HIGHER THAN REGULATORY LIMITS

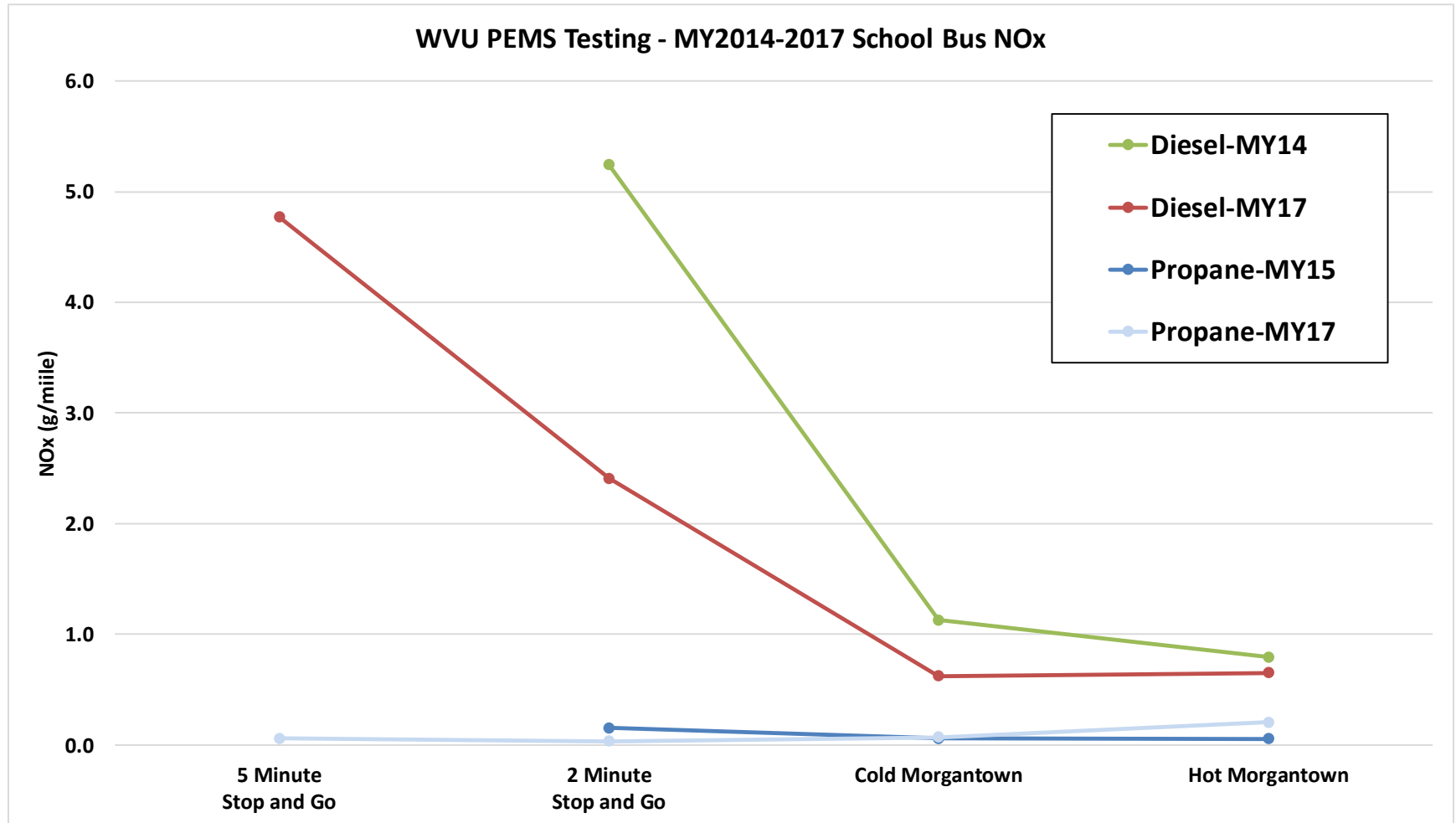


* Brake and distance specific NO_x emissions for Urban bin do not include Idle operation, only 1-25 mph operation is included

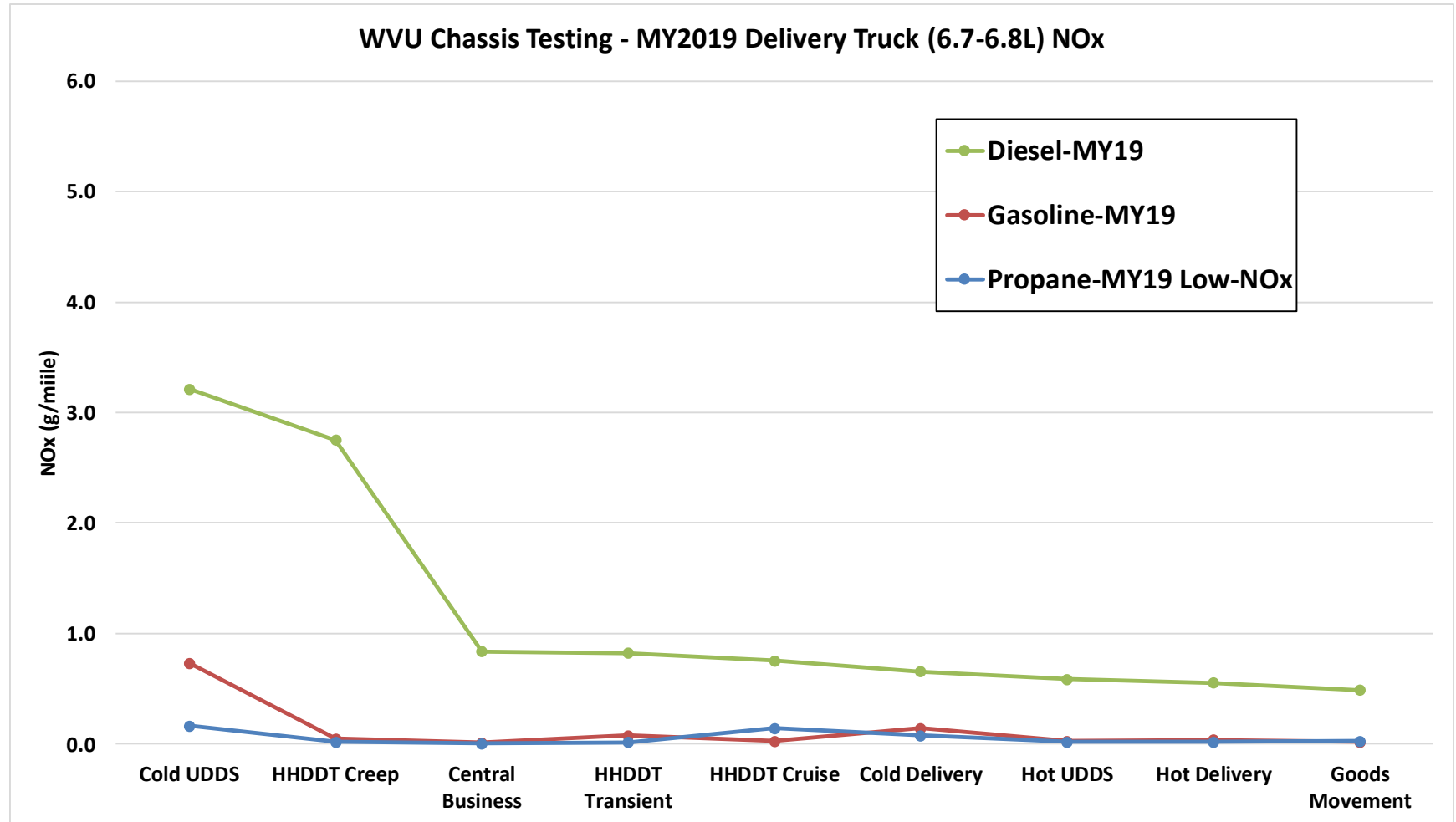
NGV NO_x CONSISTENTLY LOWER THAN DIESEL



SIGNIFICANT NO_x BENEFIT FOR PROPANE VS DIESEL



LOW-NO_x PROPANE SHOWS “NEAR ZERO” EMISSIONS



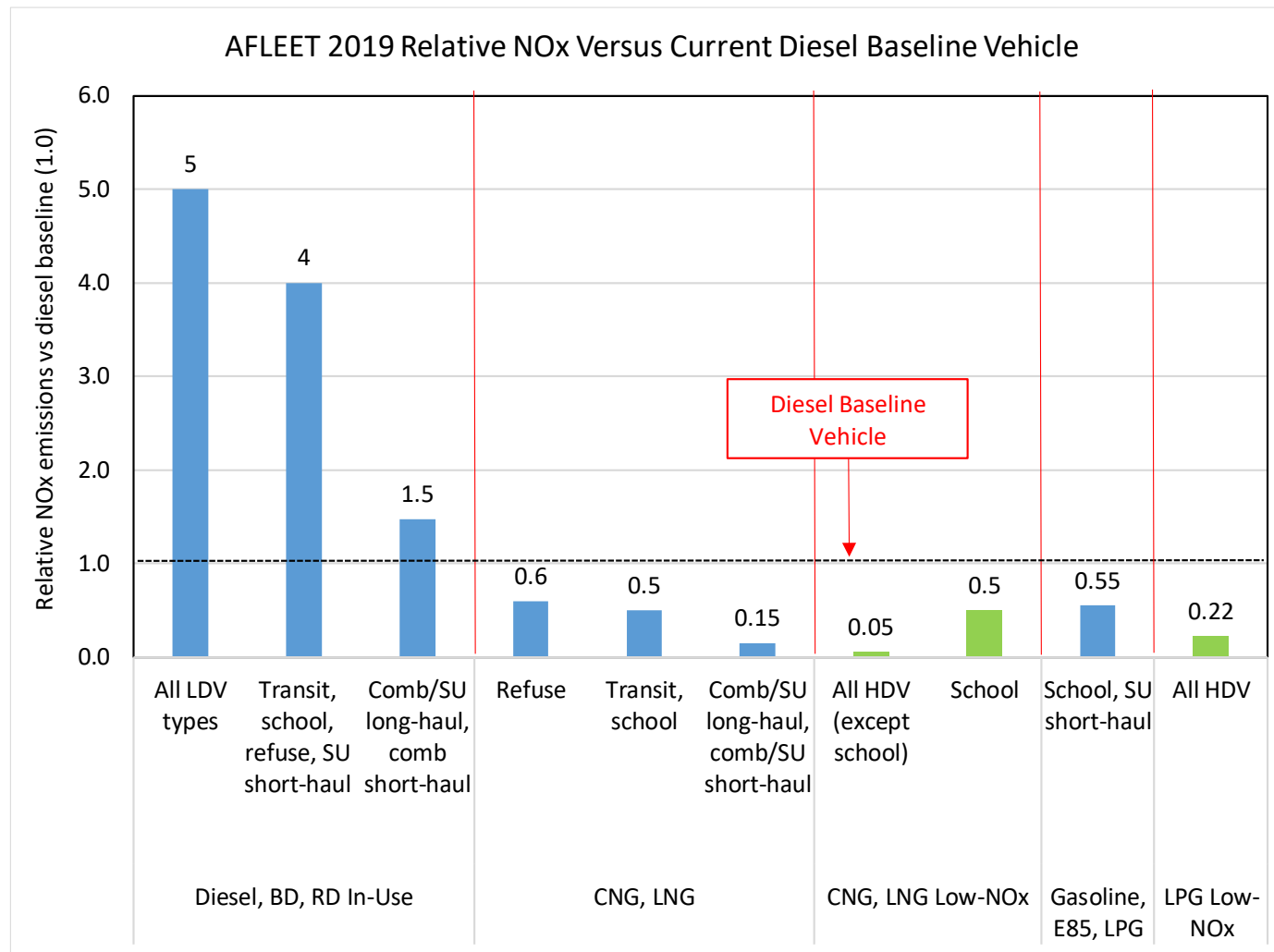
AFLEET TOOL 2019 – DIESEL IN-USE & LOW-NO_x EMISSIONS

▪ Diesel in-use NO_x feature

- EPA's MOVES (& DEQ) needs to revise diesel NO_x

▪ Heavy-duty low-NO_x feature

- Added LPG Low-NO_x in AFLEET 2019



Anenberg, 2017, Impacts and mitigation of excess diesel-related NO_x emissions in 11 major vehicle markets
doi:10.1038/nature22086;

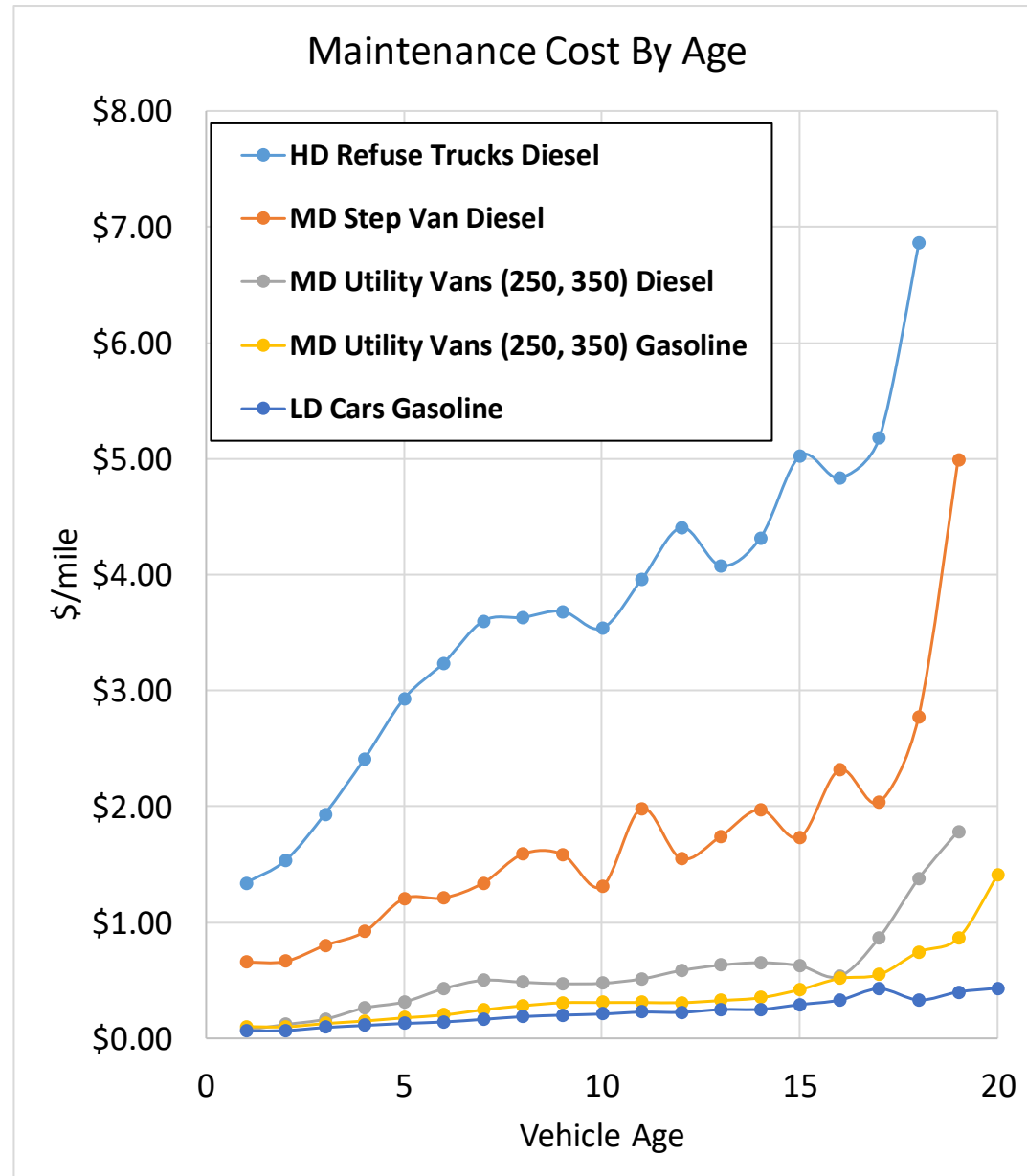
Cai, 2017, Wells to Wheels: Environmental Implications of Natural Gas As A Transportation Fuel

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

AFLEET TOOL 2019 UPDATES – VEHICLE & FUEL DATA

- **Updated petroleum use, GHGs, air pollutants factors from Argonne's GREET 1 2019**
 - Updated fuel economy data
- **Updated vehicle air pollutant emission factors from EPA's MOVES 2014b**
- **Updated fuel prices using Clean Cities Alternative Fuel Price Reports**
- **Update vehicle maintenance costs**
 - Ongoing VTO TCO analysis



AFLEET TUTORIAL – DEMO #1

Using the EV Charging Calculator to Examine Charging Benefits



AFLEET TUTORIAL – EV CHARGING CALCULATOR

■ 1st step: enter location on “Inputs” sheet

Primary Vehicle Location		
State	CALIFORNIA	
County	LOS ANGELES	

■ 2nd step: adjust electricity & 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)	

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

AFLEET TUTORIAL – EV CHARGING CALCULATOR

▪ 3rd step: enter key EV charging inputs on “Inputs” sheet

- Default predicted weekly utilization (via drop-down)
- # of chargers, weekly utilization, session power, & charge time
- Can simulate both an L2 and DC Fast chargers

Level 2 Charging Infrastructure				
Predicted Weekly Utilization	Moderate			
Venue	Number of Chargers	Weekly Utilization (sessions/week/ station)	Average Session Power (kW)	Charge Time (minutes/ session)
Parking Lot	1	4.5	4	150
Retail & Leisure	2	5.5	4	90
Education	3	6.0	4	150
Healthcare	4	6.5	4	150
Workplace	5	4.5	4	150
Multi-Unit Dwelling	6	3.0	4	210
Single-Unit Dwelling	7	6.0	4	120

DC Fast Charging Infrastructure				
Predicted Weekly Utilization	Moderate			
Venue	Number of Chargers	Weekly Utilization (sessions/week/ station)	Average Session Power (kW)	Charge Time (minutes/ session)
Parking Lot	1	15.0	24	22
Retail & Leisure	2	15.0	24	22
Education	3	15.0	24	22
Healthcare	4	15.0	24	22
Workplace	5	15.0	24	22
Multi-Unit Dwelling	6	15.0	24	22
Single-Unit Dwelling	1	15.0	24	22

Note: Red cells show values changed for demo, cell color doesn't change in AFLEET

AFLEET TUTORIAL – EV CHARGING CALCULATOR

- 4th step (optional): view detailed “EV Charging” sheet

	Parking Lot	Retail & Leisure	Education	Healthcare	Workplace	Multi-Unit Dwelling	Single-Unit Dwelling
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	1	2	3	4	5	6	7
Weekly Utilization (sessions/week)	4.5	5.5	6.0	6.5	4.5	3.0	6.0
Daily Utilization (sessions/day)	0.6	0.8	0.9	0.9	0.6	0.4	0.9
Average Session Power (kW)	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Average Charge Time (hours/session)	2.5	1.5	2.5	2.5	2.5	3.5	2.0
Electricity Dispensed (kWh/session)	10.0	6.0	10.0	10.0	10.0	14.0	8.0
Electricity Dispensed (kWh/day)	6.4	9.4	25.7	37.1	32.1	36.0	48.0
Electricity Dispensed (kWh/year)	2,346	3,441	9,386	13,557	11,732	13,140	17,520
Annual EV Miles from L2 Charging	6,661	9,770	26,645	38,487	33,306	37,303	49,737

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

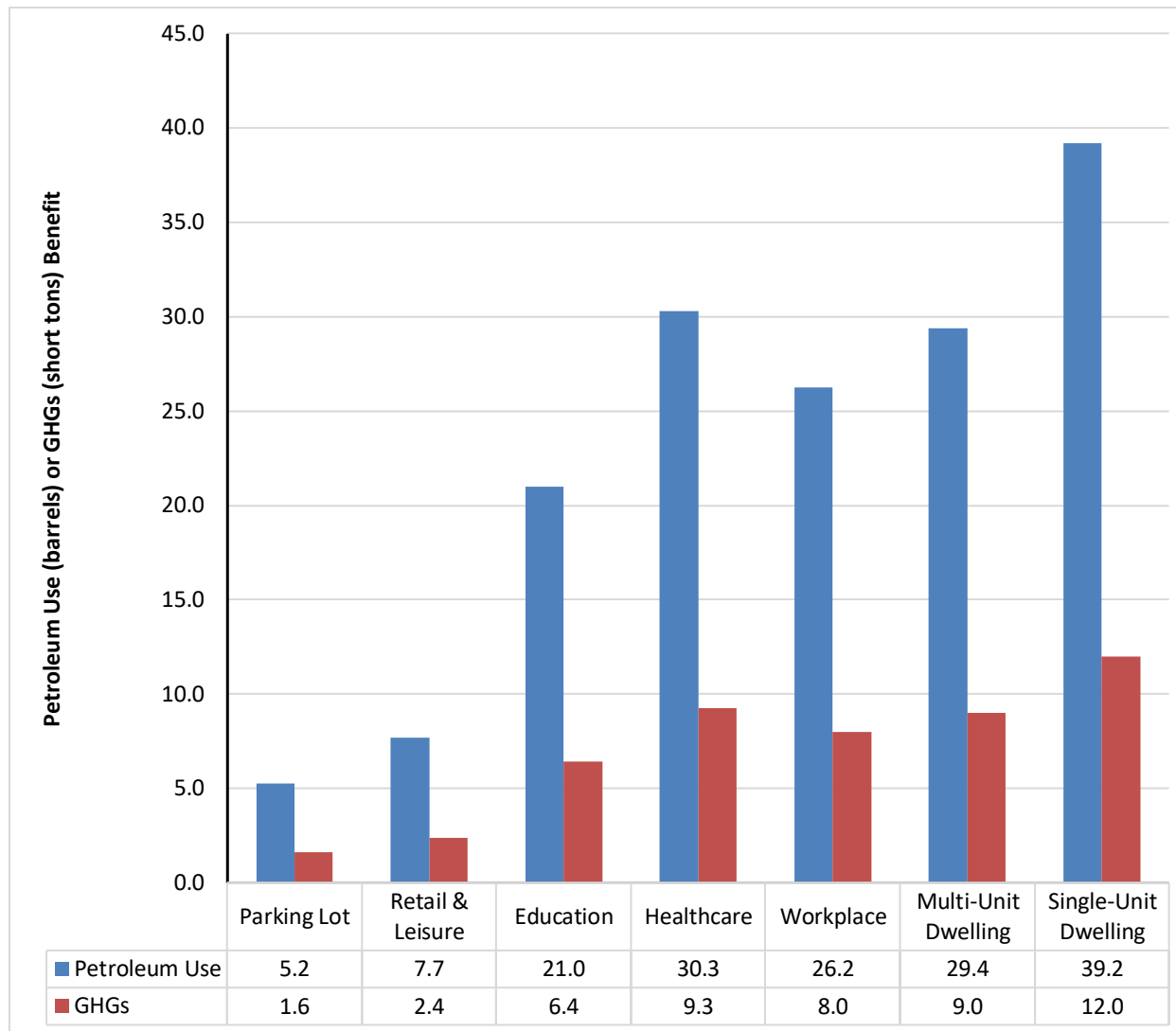
AFLEET TUTORIAL – EV CHARGING CALCULATOR

▪ View results on “EV Charging Outputs” sheet

Venue	Petroleum Use (barrels)	GHGs (short tons)	CO (lb)	NOx (lb)	PM10 (lb)	PM2.5 (lb)	VOC (lb)	SOx (lb)	Electricity Dispensed (kWh)
Level 2 Chargers									
Parking Lot	5.2	1.6	22.6	1.7	-0.1	0.1	4.2	-4.2	2,346
Retail & Leisure	7.7	2.4	33.2	2.5	-0.1	0.1	6.2	-6.1	3,441
Education	21.0	6.4	90.5	6.8	-0.2	0.2	16.8	-16.7	9,386
Healthcare	30.3	9.3	130.7	9.8	-0.3	0.3	24.2	-24.2	13,557
Workplace	26.2	8.0	113.1	8.5	-0.3	0.3	21.0	-20.9	11,732
Multi-Unit Dwelling	29.4	9.0	126.7	9.5	-0.3	0.3	23.5	-23.4	13,140
Single-Unit Dwelling	39.2	12.0	168.9	12.7	-0.4	0.4	31.3	-31.2	17,520
L2 Charger Total	159.1	48.6	685.6	51.6	-1.7	1.8	127.1	-126.7	71,123
DC Fast Chargers									
Parking Lot	15.1	4.6	65.1	4.9	-0.2	0.2	12.1	-12.0	6,758
Retail & Leisure	30.2	9.2	130.3	9.8	-0.3	0.3	24.2	-24.1	13,515
Education	45.3	13.9	195.4	14.7	-0.5	0.5	36.2	-36.1	20,273
Healthcare	60.5	18.5	260.6	19.6	-0.7	0.7	48.3	-48.2	27,031
Workplace	75.6	23.1	325.7	24.5	-0.8	0.9	60.4	-60.2	33,789
Multi-Unit Dwelling	90.7	27.7	390.8	29.4	-1.0	1.0	72.5	-72.3	40,546
Single-Unit Dwelling	15.1	4.6	65.1	4.9	-0.2	0.2	12.1	-12.0	6,758
DC Fast Charger Total	332.5	101.6	1,433.1	108.0	-3.6	3.8	265.7	-264.9	148,670

AFLEET TUTORIAL – EV CHARGING CALCULATOR

- View results on “EV Charging Outputs” sheet



AFLEET TUTORIAL – DEMO #2

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

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						
				Gasoline (gal)	Diesel (gal)	Electricity (kWh)	G.H2 (kg)	B20 (gal)	B100 (gal)	RD20 (gal)
Aerial Lifts	2005	361	41	154						
Aerial Lifts	2005	361	41	154		1,269				
Agricultural Tractors	2005	55	65	50						
Agricultural Tractors	2005	55	65	50						
Airport Support Equipment	2005	681	43	372						
Airport Support Equipment	2005	681	43	372						
All Terrain Vehicles	2005	3,216	2	146						
All Terrain Vehicles	2005	3,216	2	146						
Chain Saws	2005	33	3	2						
Chain Saws	2005	33	3	2						
Commercial Turf Equipment	2005	1,364	25	464						
Commercial Turf Equipment	2005	1,364	25	464						
Cranes	2005	99	365		500					
Cranes	2005	99	365		500					

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

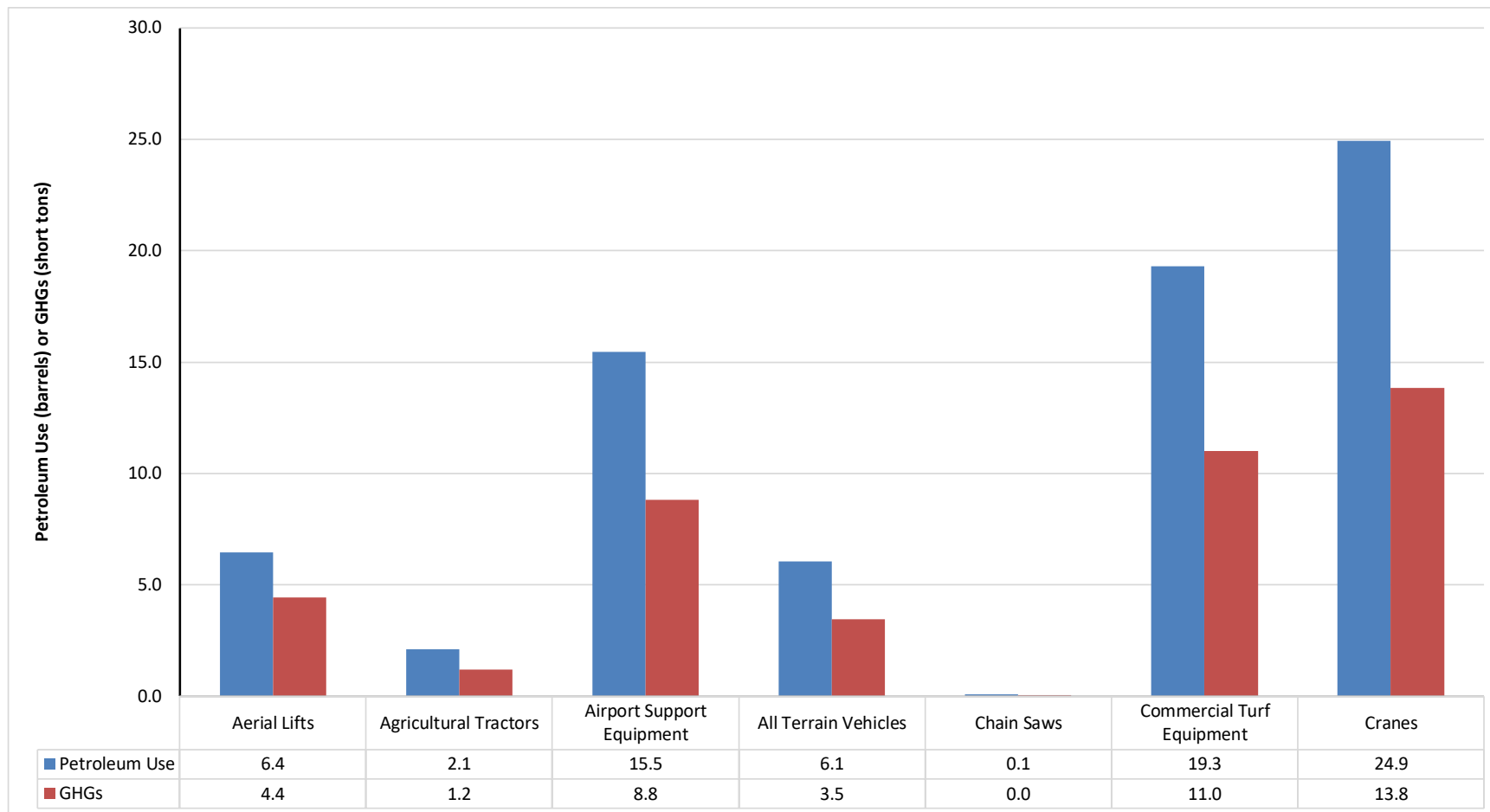
AFLEET TUTORIAL – OFF-ROAD FLEET FOOTPRINT CALCULATOR

- 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



THANK YOU!!!

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