Greenhouse Gases and Propane Vehicles

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Propane Autogas Technology Forum
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Agenda

- **Transportation Greenhouse Gas Emissions**
- **AFLEET Update**

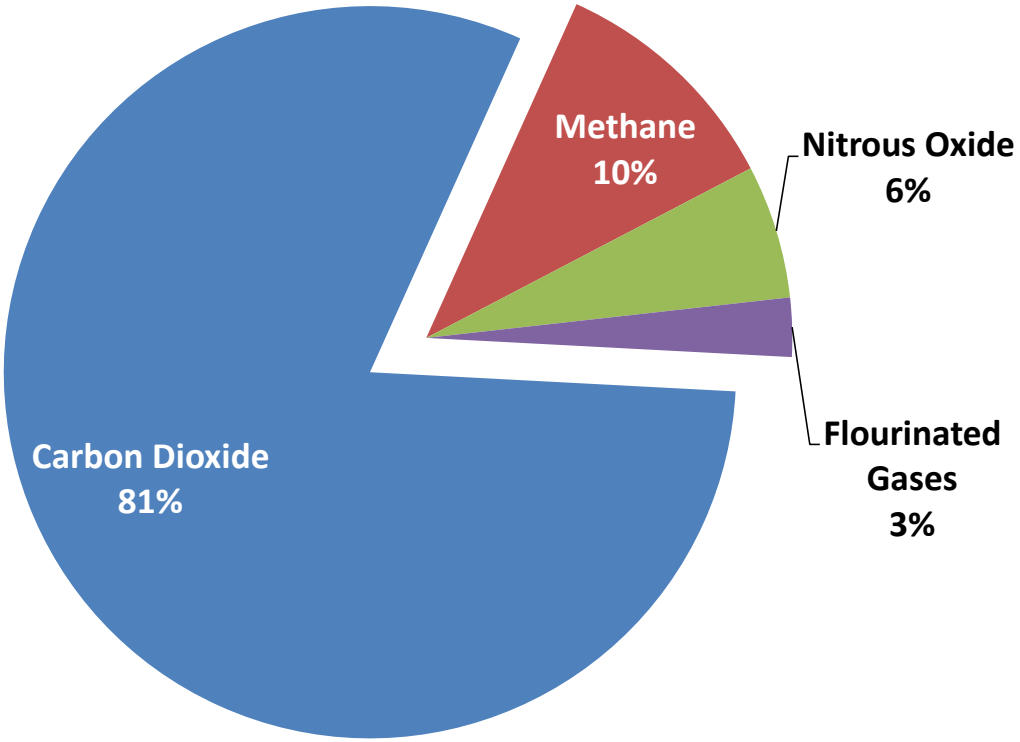
Transportation Greenhouse Gas Emissions

Key Greenhouse Gases Impacting Climate Change

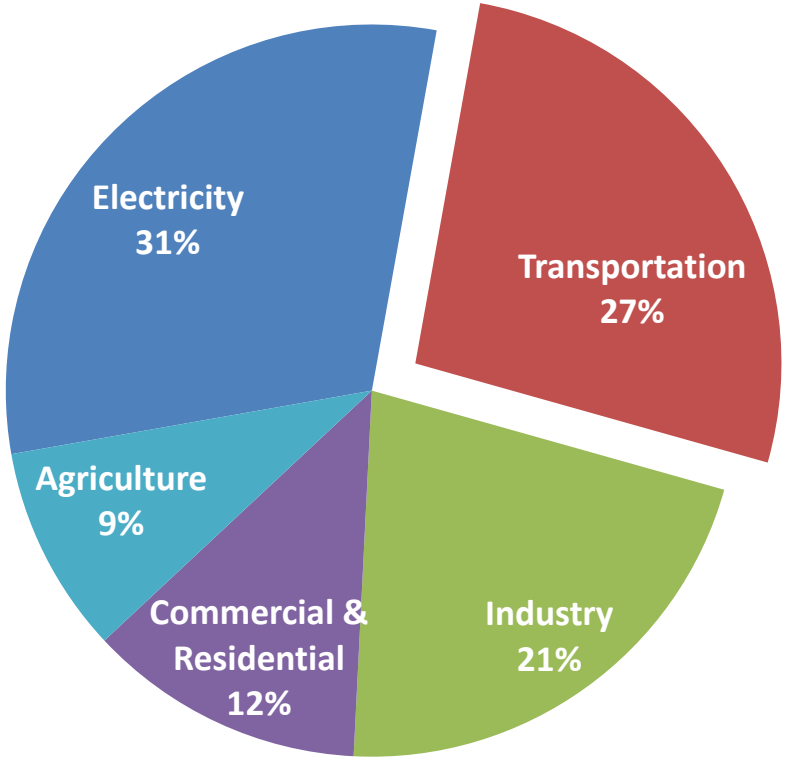
- **Carbon dioxide (CO_2)**
  - Produced via fossil- & bio-fuel combustion
  - Sequestered by plants as part of biological carbon
  - GWP = 1
- **Methane (CH_4)**
  - Emitted via production, transport & use of fossil fuels
  - Livestock and decay of organic waste in landfills
  - GWP = 30
- **Nitrous oxide (N_2O)**
  - Emitted via agricultural activities
  - Fossil- & bio-fuel combustion
  - GWP = 265
- **Fluorinated gases (HFCs, PFCs, SF_6, NF_6)**
  - Synthetic gases emitted from industrial processes
  - Refrigerants for air conditioning in vehicles
  - GWP = 4,660 – 23,500

Transportation Accounts for Large Portion of US GHGs

2014 US GHGs by Gas



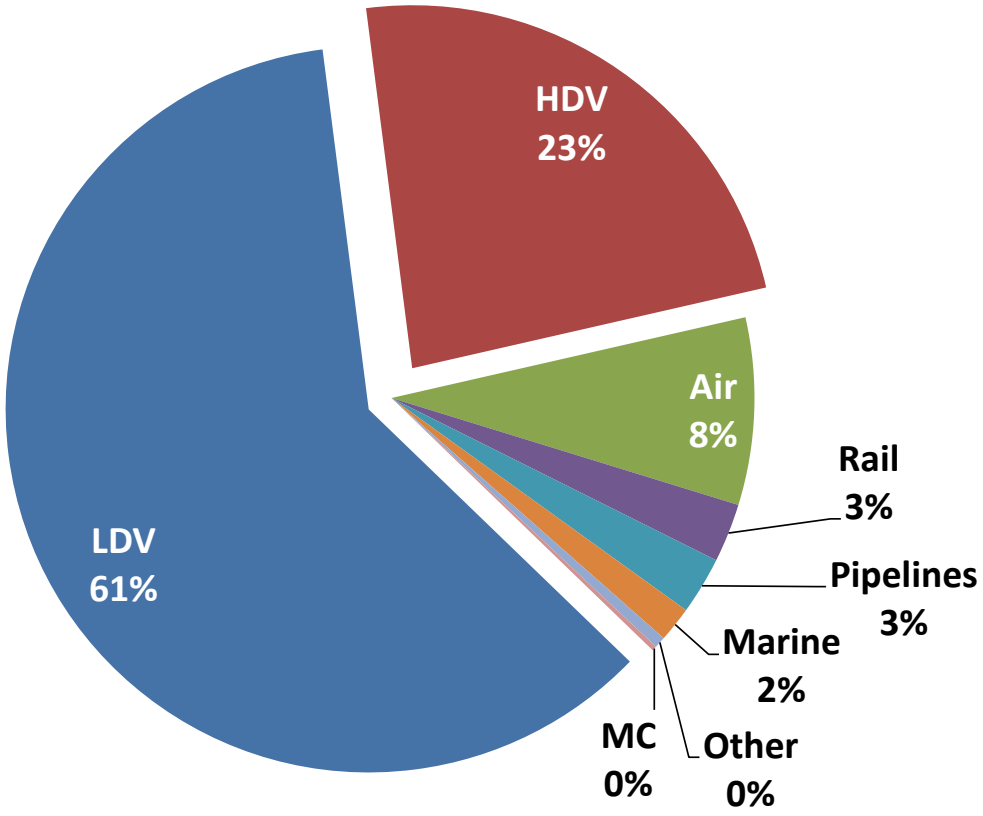
2014 US GHGs by Sector



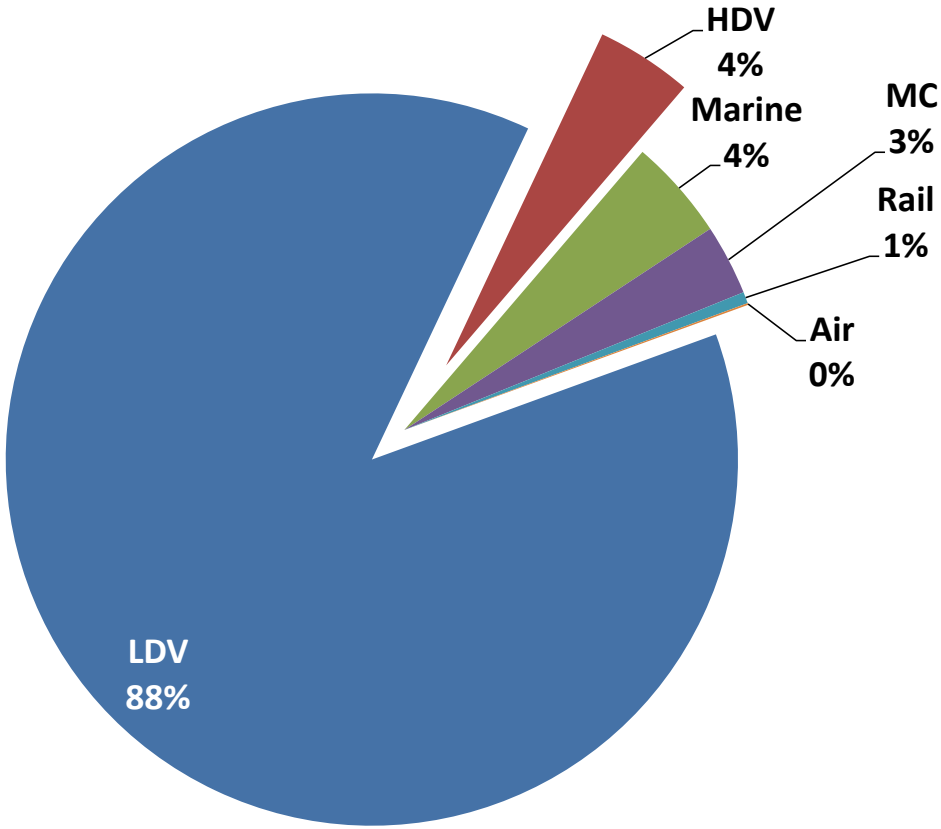
- **2014 US GHGs = 7.5 billion tons**

LDVs Account for Majority of GHGs, but Small # of HDVs have Significant Impacts

2014 US GHGs by Transportation Sector



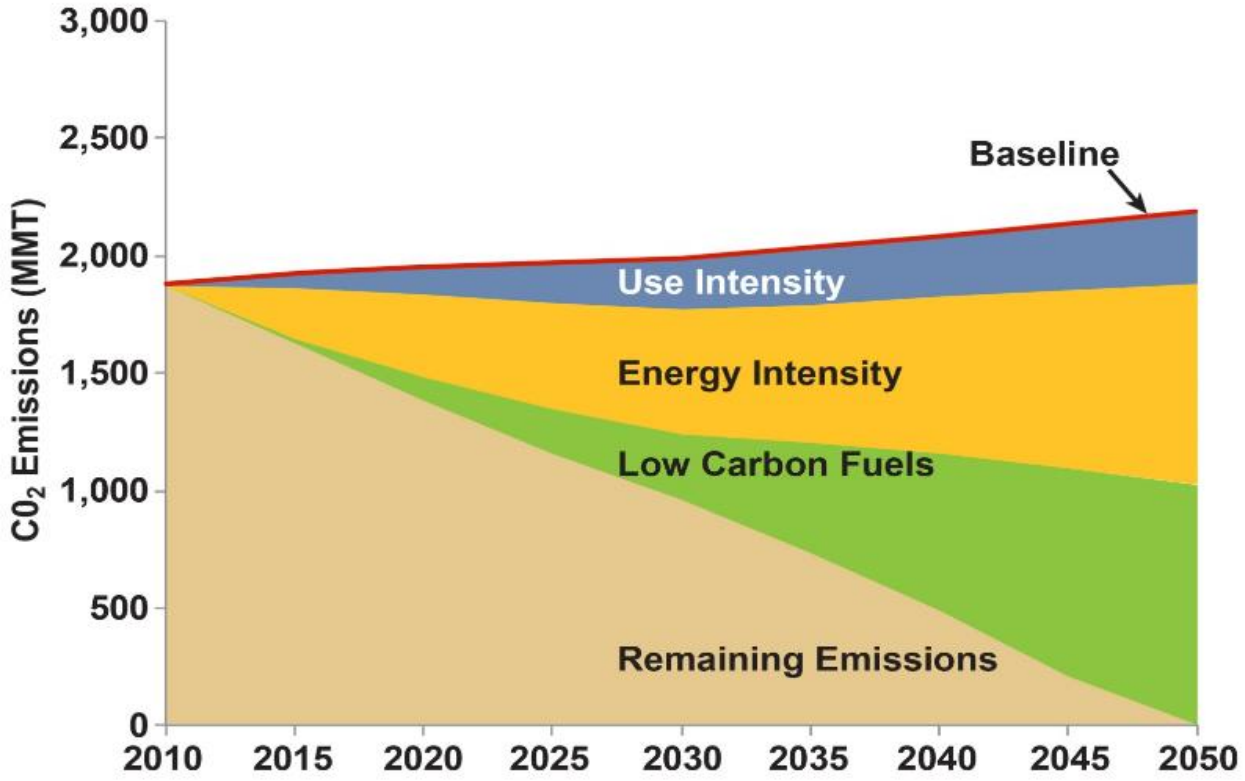
2013 US Vehicles by Type



- 2014 US Transportation GHGs = 2 billion tons

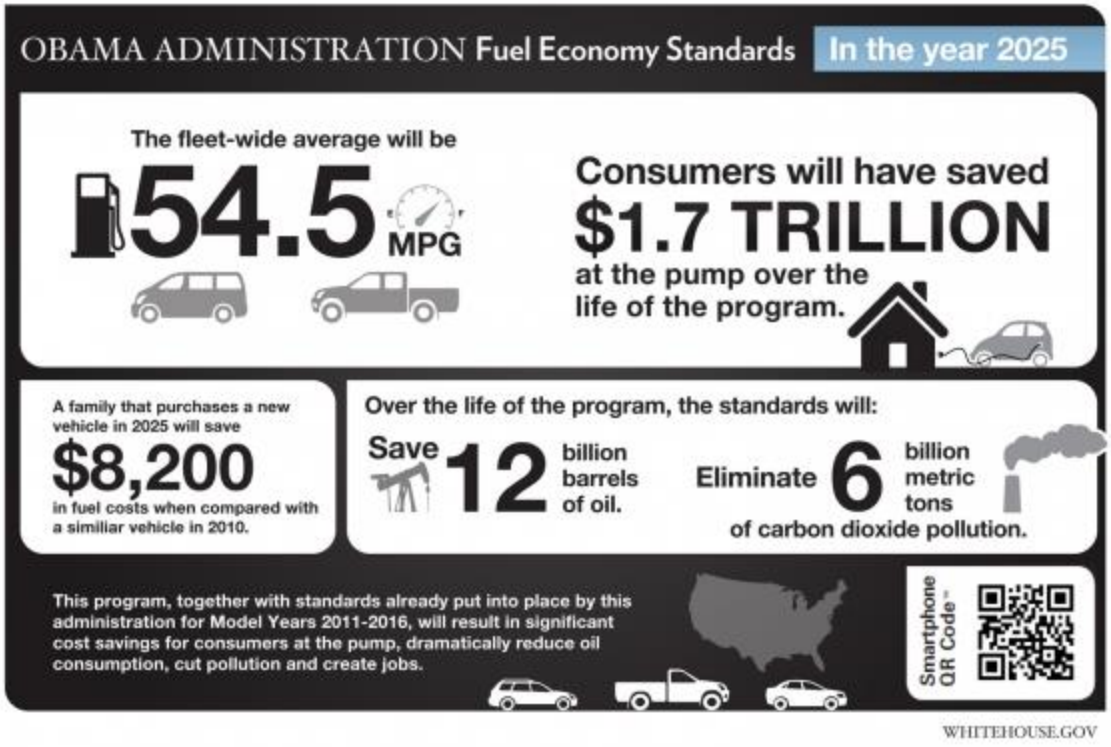
U.S. COP21 (Paris Agreement) & White House GHG Goals

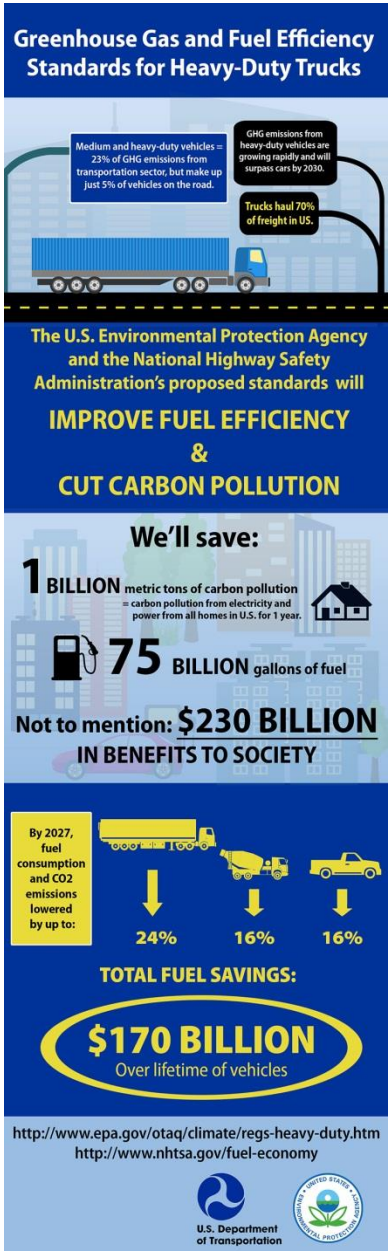
- **Reduce GHG emissions by 17% by 2020, 26-28% by 2025 and 83% by 2050 from 2005 baseline**
- **Reducing transportation emissions can be addressed via demand, efficiency & LCFs**



Vehicle Tailpipe GHG Standards

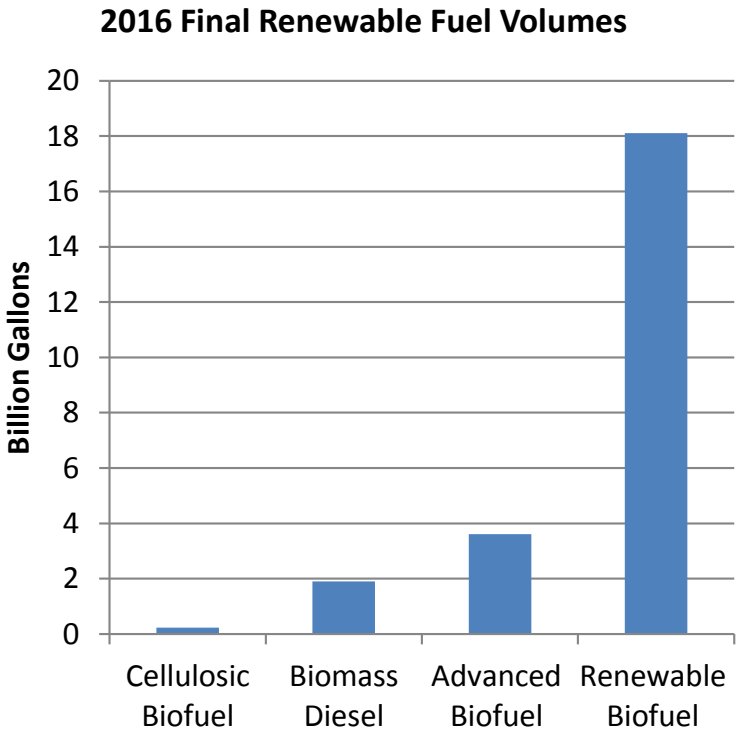
- **Light-Duty Reductions - EPA**
  - Phase 1 - MY2012->2016 = 15%
  - Phase 2 = MY2017->2025 = 33%





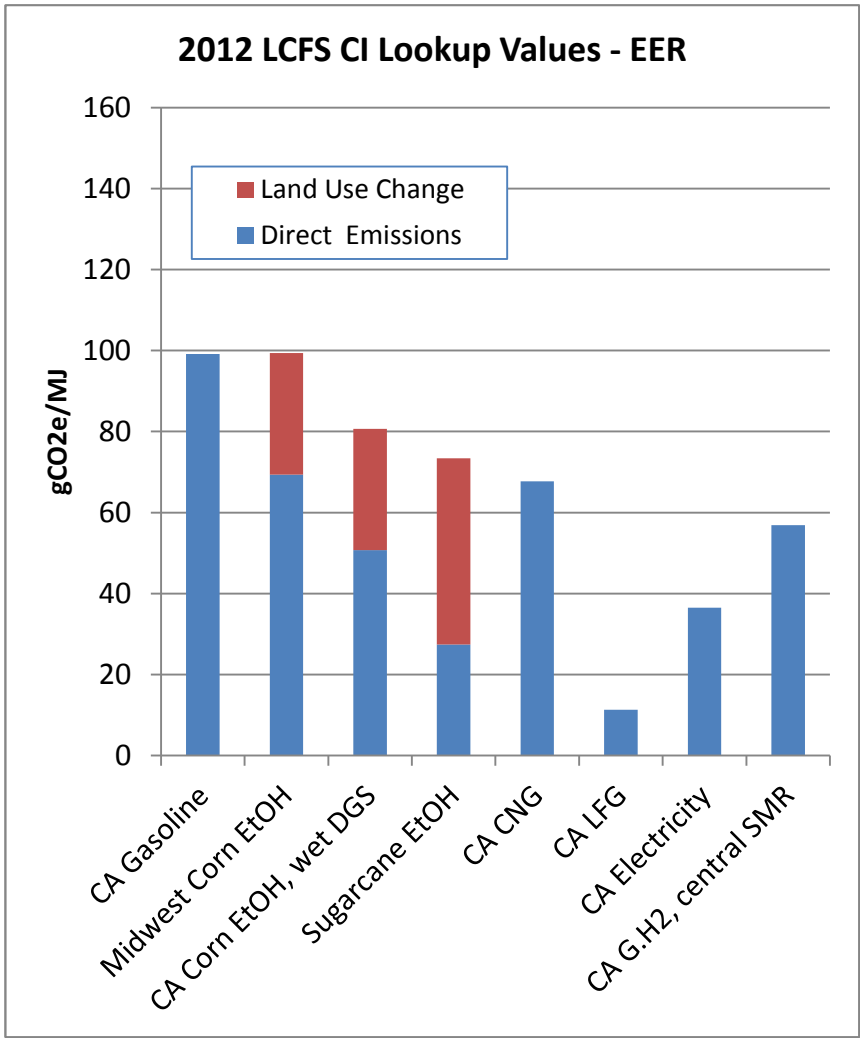
Renewable and Low-Carbon Fuel Life-Cycle GHG Standards

- **Renewable Fuel Standard (RFS2) - EPA**
  - Volumes set by EPA each year
    - Goal to meet 36 billion gallons by 2022
  - Each fuel category required to meet GHG reductions vs. gasoline/diesel
    - Renewable (corn EtOH) = 20%
    - Advanced (cellulosic/biomass-based diesel) = 50%
    - Biomass-based diesel (BD & RD) = 50%
    - Cellulosic (cellulosic EtOH & RNG) = 60%
      - 2016 RNG RIN credit = $2.70/GGE



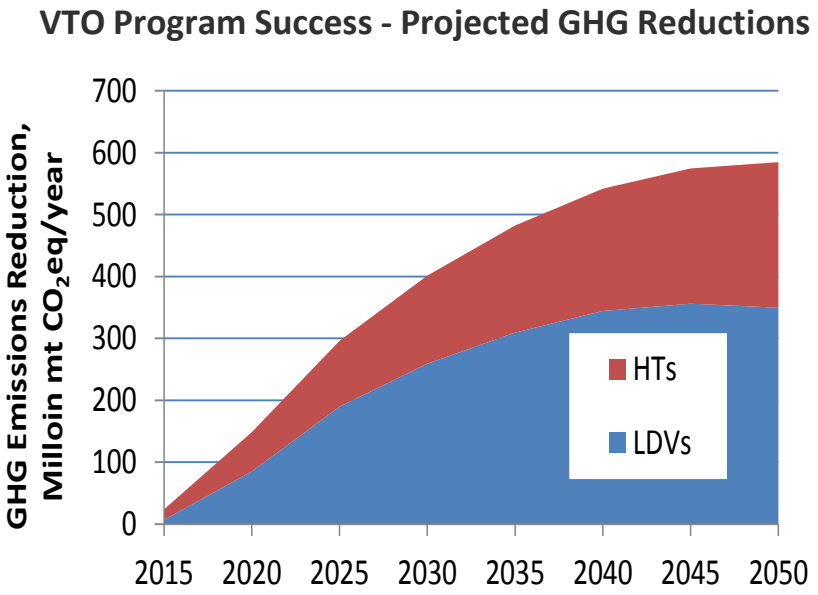
Renewable and Low-Carbon Fuel Life-Cycle GHG Standards

- **Low Carbon Fuel Standard - CARB**
  - 10% reduction in carbon intensity (CI) of CA fuel supply by 2020
    - Other PNW and NE states developing programs
  - No specific volumes of any fuels required
  - Fuel CI calculated via CA-GREET
  - Fuel carbon intensity can be adjusted with vehicle efficiency (EER)
  - 2016 CNG LCFS credit ~ $0.40/GGE
  - 2016 RNG LCFS credit ~ $1.20/GGE



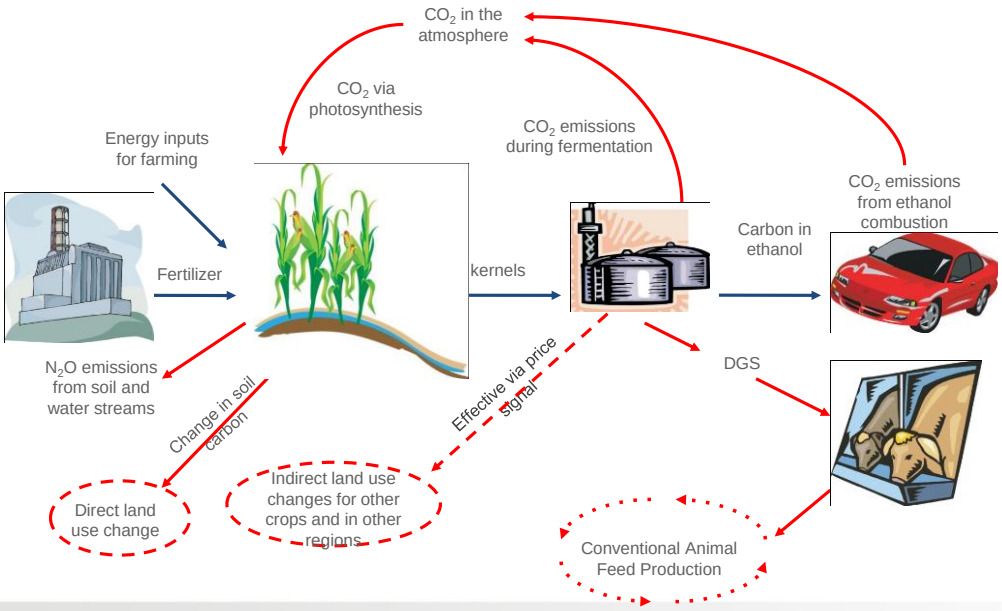
Other GHG Regulations and Programs

- **Clean Power Plan - EPA (pending)**
  - Reduce electricity GHGs 32% from 2005 levels by 2030
- **Methane Challenge Program - EPA**
  - Voluntary program to reduce CH4 emissions from the oil and gas sector by 40-45% from 2012 levels by 2025
- **Research, development, demonstration & deployment – DOE**
  - VTO, BETO, FCT
- **Numerous state & regional initiatives**
  - Fuels
  - Vehicles
  - VMT

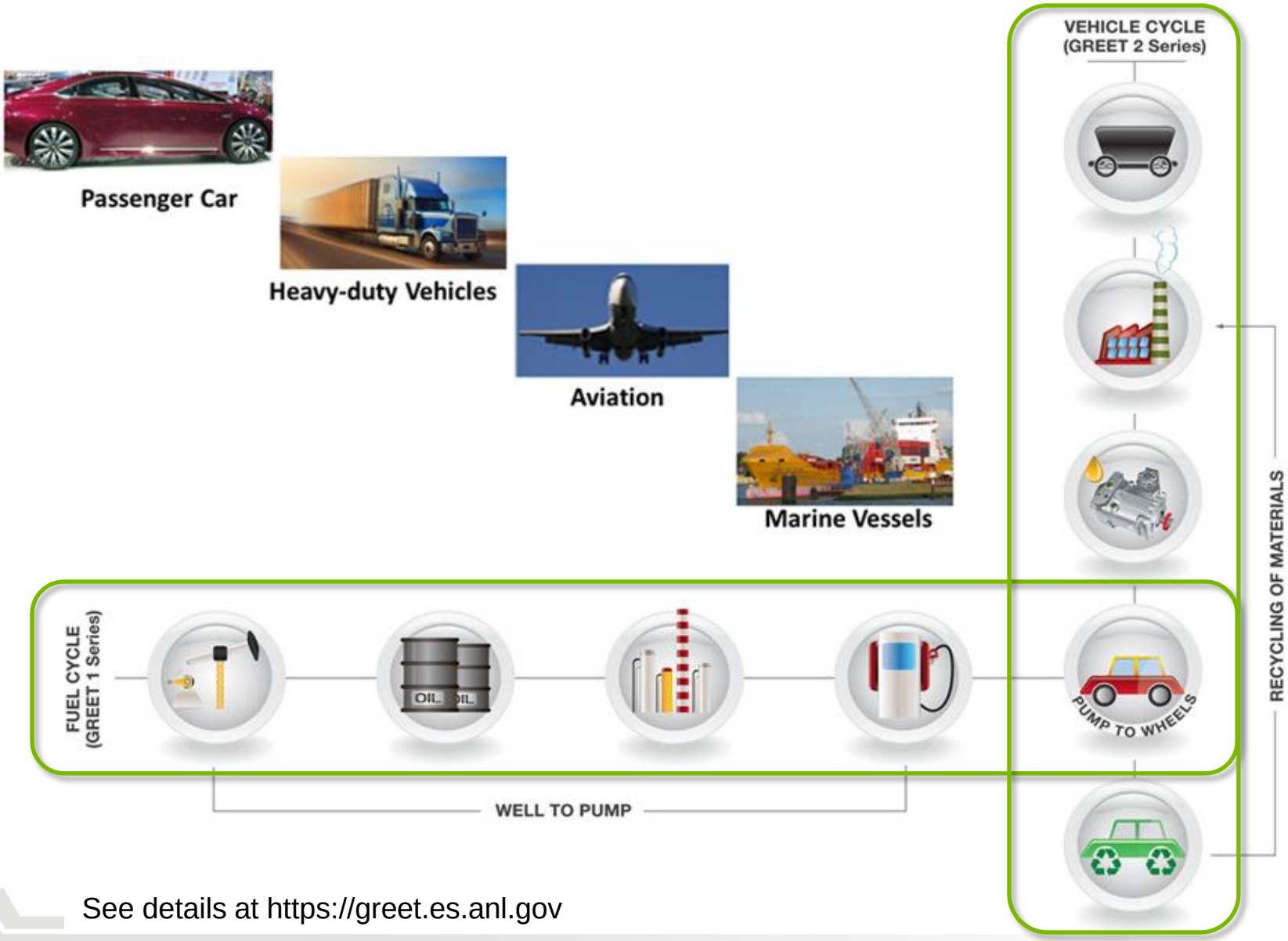


Life-Cycle Analysis for Vehicle/Fuel Systems Has Evolved in the Past 30 Years

- **Pursuing transportation GHG emissions reductions requires WTW analysis**
- **Pioneering WTW analyses began in 1980s**
  - Early studies were motivated primarily by battery-powered EVs
- **Recent studies are motivated primarily by introduction of:**
  - New fuels such as cellulosic ethanol and hydrogen
  - New vehicle technologies such as plug-in hybrids

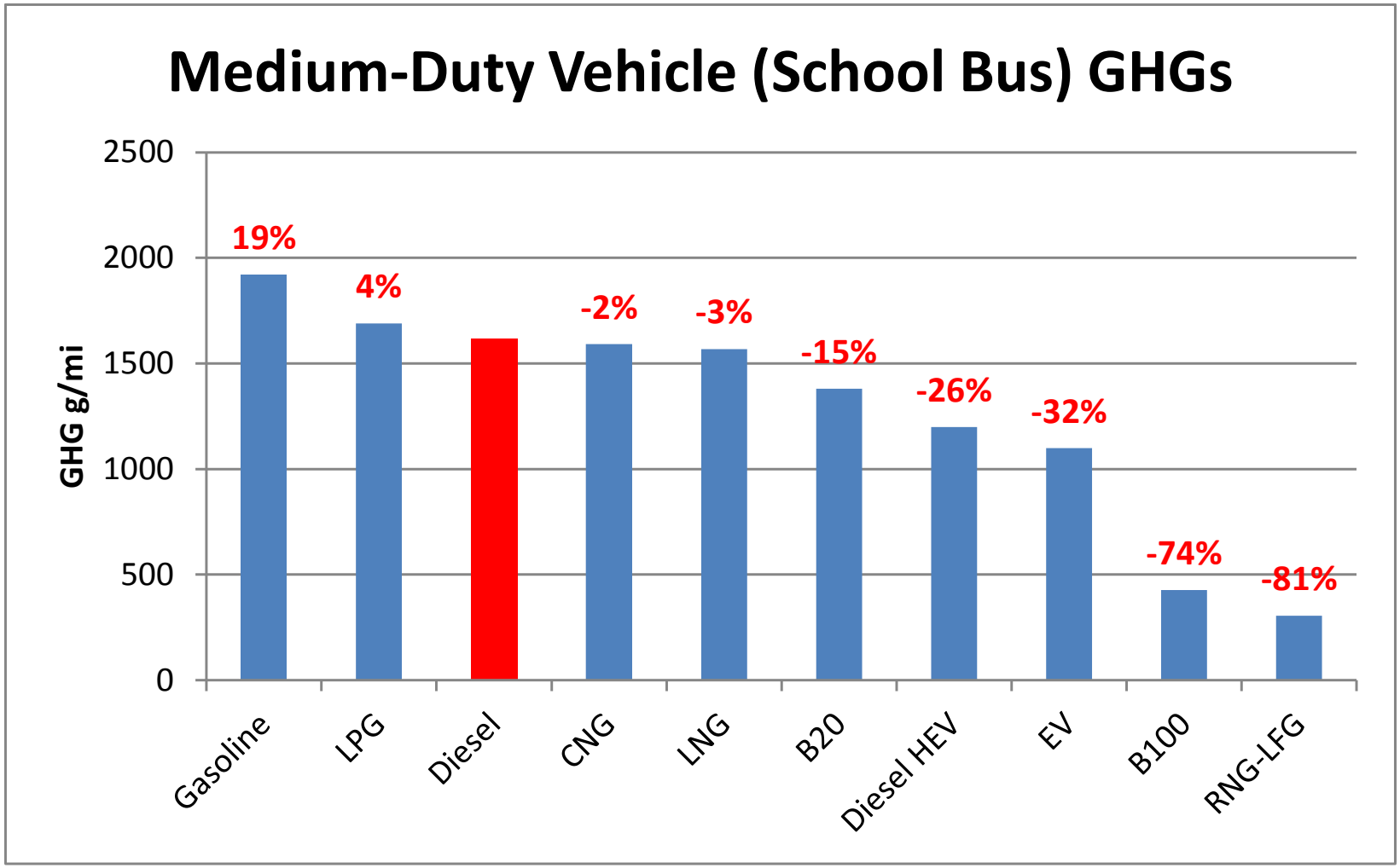


The GREET Model at Argonne National Laboratory

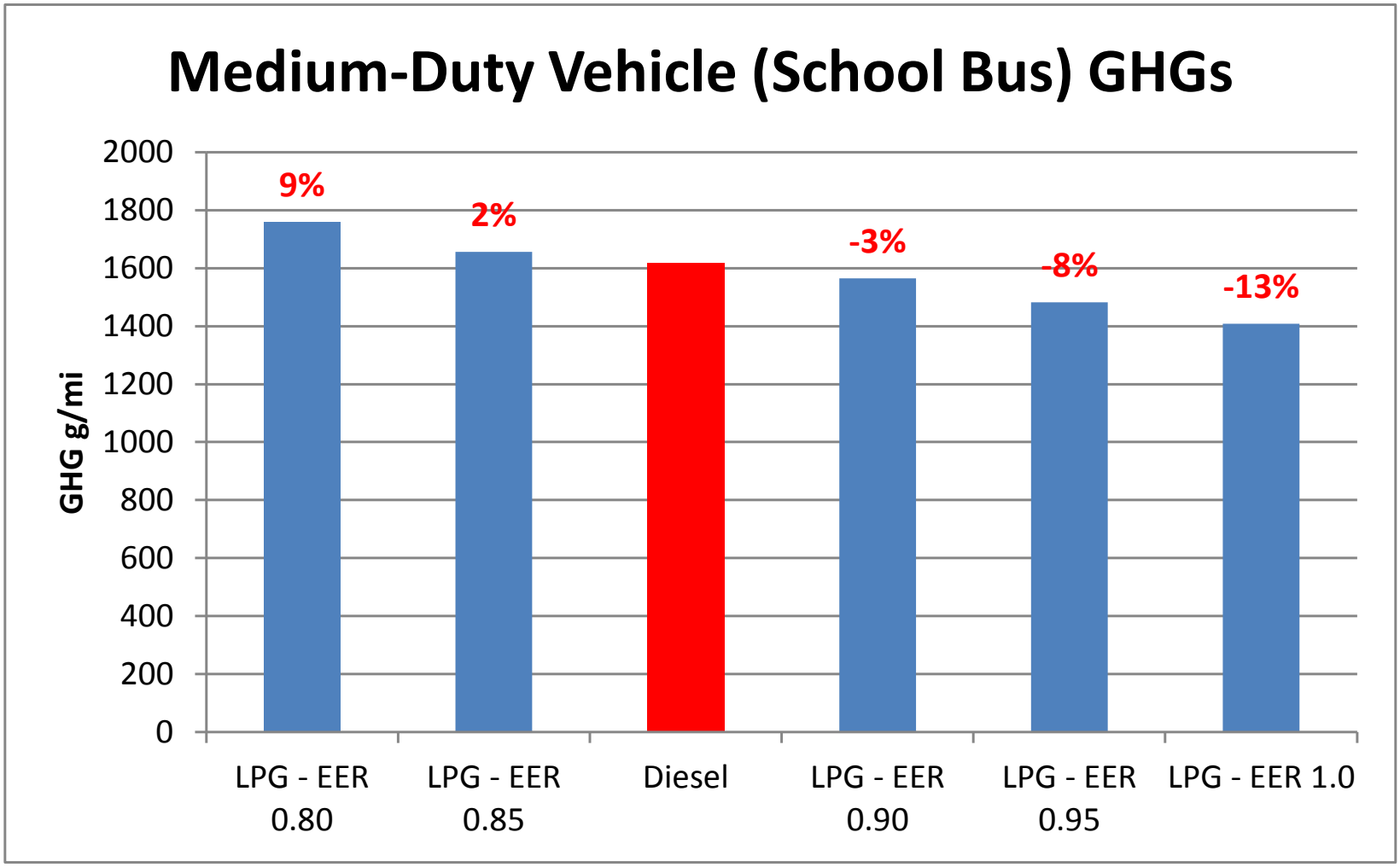


See details at https://greet.es.anl.gov

Life-Cycle GHGs Depend on Both CI and Fuel Efficiency



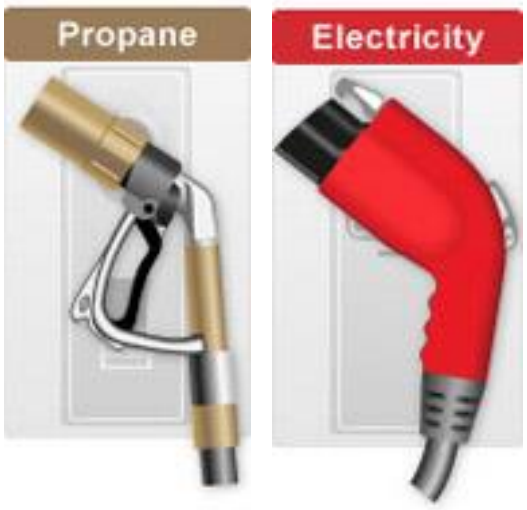
Fuel Economy Impacts of MD/HD LPG GHGs vs Diesel



AFLEET Tool Update

“AFLEET Tool” to Analyze Costs & Benefits of AFVs

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



- **Contains 16 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, H_2, LPG, CNG, LNG, LNG/diesel pilot ignition
- **Includes 7 Major Vehicle Types**
  - Cost, MPG, & VMT data on 23 vocations
- **AFLEET Tool 2016 & its user manual available at:**
  http://greet.es.anl.gov/afleet

AFLEET Tool 2016 Updates - Fuel & Infrastructure

- **Added private station pricing from Clean Cities Alternative Fuel Price Report**
  - Can investigate a range of fuel prices for simple payback
- **Added refueling station and EVSE infrastructure construction, operation, and maintenance costs**

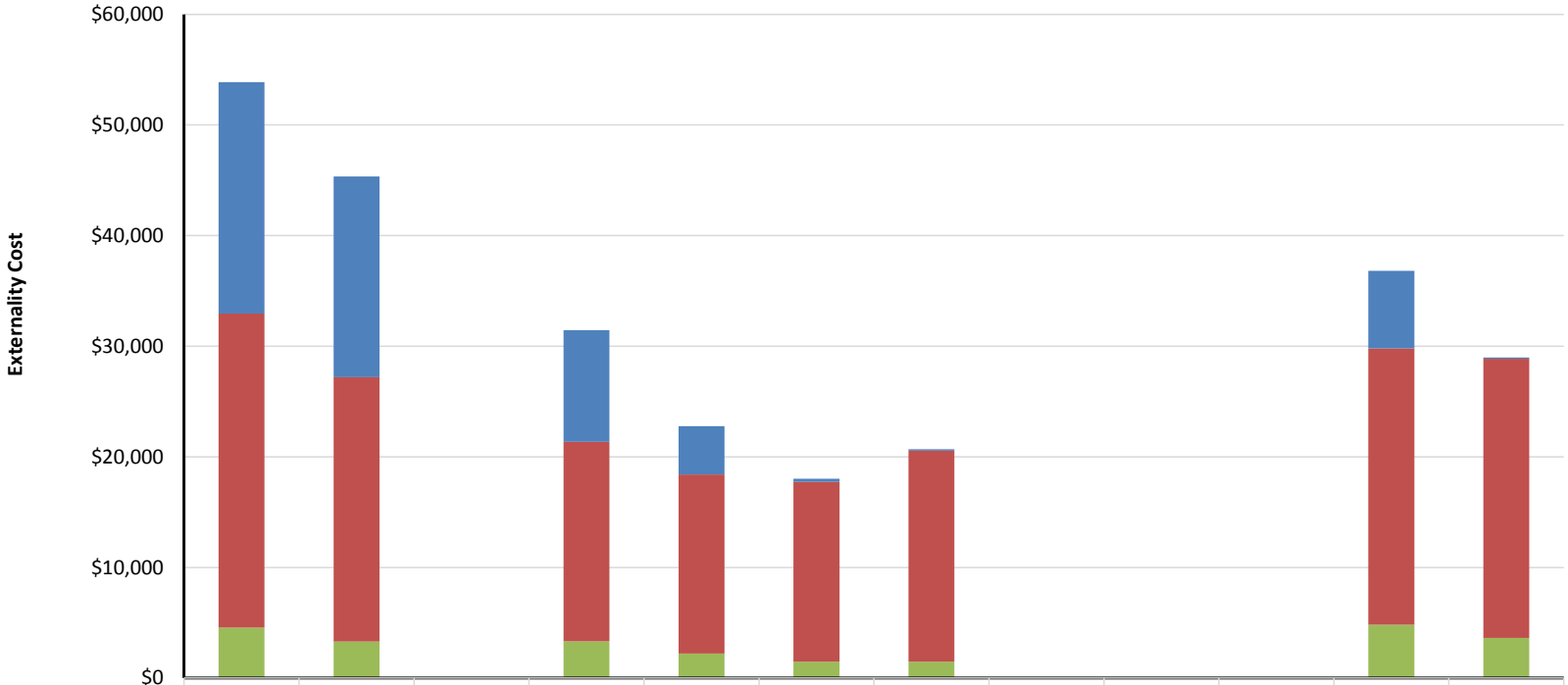
AFLEET Tool 2016 Updates – Vehicle & Emission Data

- **Updated petroleum use, GHG emissions, and relative air pollutant emissions from Argonne's GREET 1 2015**
  - GREET 1 heavy-duty module fuel economy and emissions data
- **Updated vehicle air pollutant emission factors from EPA's MOVES 2014a**

GREET
LIFE-CYCLE MODEL

AFLEET Tool 2016 Updates - Externality Costs

- **Added national petroleum use and GHG emissions externality costs and county-specific air pollutant emission externality costs**
  - Added new "Output" charts incorporating externality costs



	Gasoline	Diesel	Gasoline HEV	Gasoline PHEV	Gasoline EREV	EV	G.H2 FCV	B20	B100	E85	LPG	CNG
Petroleum Use	$20,927	$18,130		$10,103	$4,358	$286	$135				$7,009	$112
GHGs	$28,379	$23,906		$18,037	$16,183	$16,240	$19,061				$24,967	$25,252
Air Pollutants	$4,576	$3,302		$3,324	$2,223	$1,490	$1,490				$4,831	$3,623

Summary

- **Transportation accounts for a large portion of US GHG emissions**
- **Policies have been developed to address these emissions**
- **Life-cycle analysis is used to analyze GHG impacts of AFVs**
- **AFLEET Tool estimates GHGs as well as other economic and environmental costs and benefits of AFVs**
- **AFLEET updated to include**
  - Private station fueling by state
  - Infrastructure costs
  - Latest vehicle and emission data
  - Externality costs

Thank you!!!

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