

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



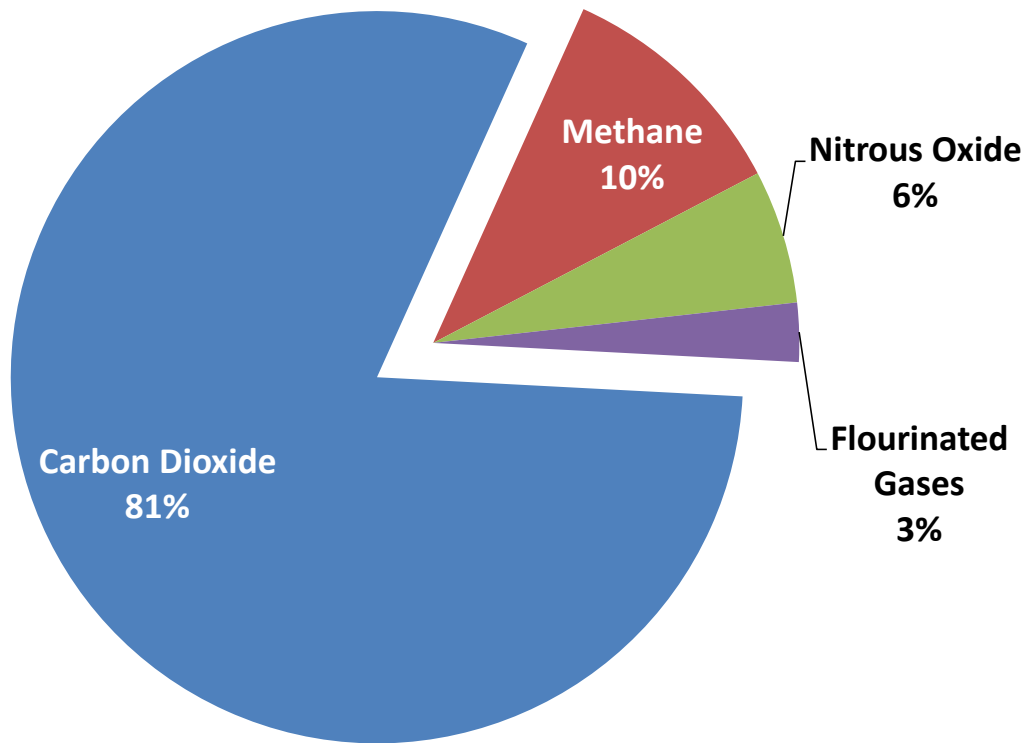
Key Greenhouse Gases Impacting Climate Change

- **Carbon dioxide (CO₂)**
 - Produced via fossil- & bio-fuel combustion
 - Sequestered by plants as part of biological carbon
 - GWP = 1
- **Methane (CH₄)**
 - Emitted via production, transport & use of fossil fuels
 - Livestock and decay of organic waste in landfills
 - GWP = 30
- **Nitrous oxide (N₂O)**
 - Emitted via agricultural activities
 - Fossil- & bio-fuel combustion
 - GWP = 265
- **Fluorinated gases (HFCs, PFCs, SF₆, NF₆)**
 - Synthetic gases emitted from industrial processes
 - Refrigerants for air conditioning in vehicles
 - GWP = 4,660 – 23,500

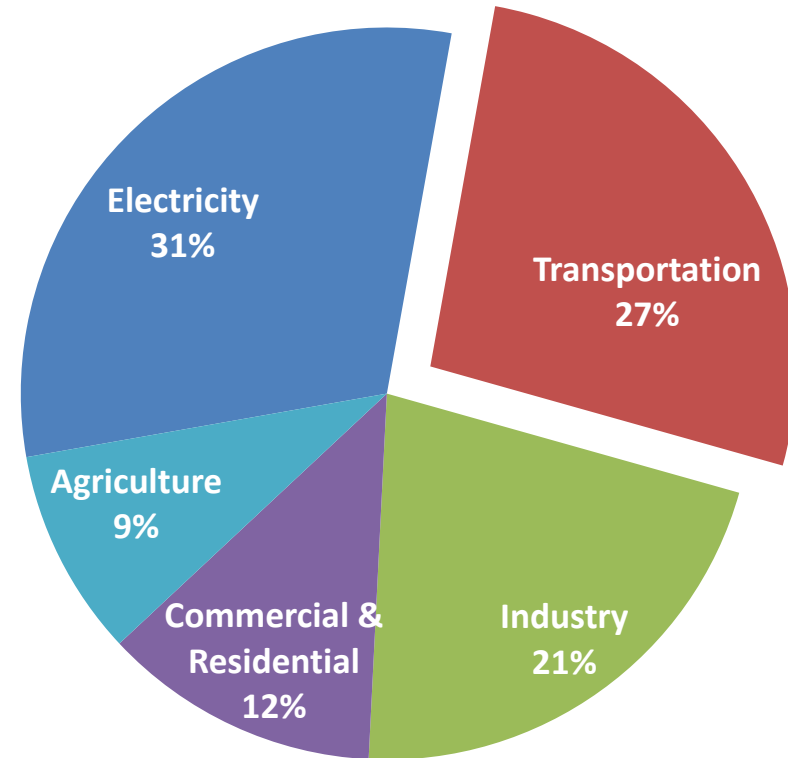


Transportation Accounts for Large Portion of US GHGs

2014 US GHGs by Gas



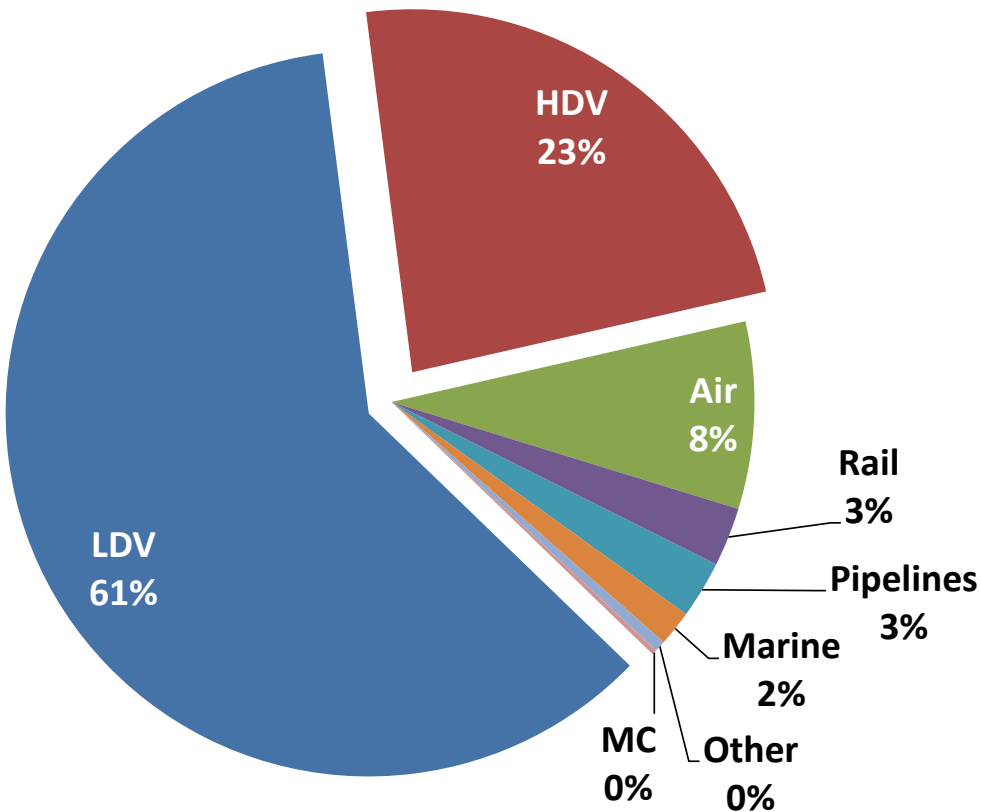
2014 US GHGs by Sector



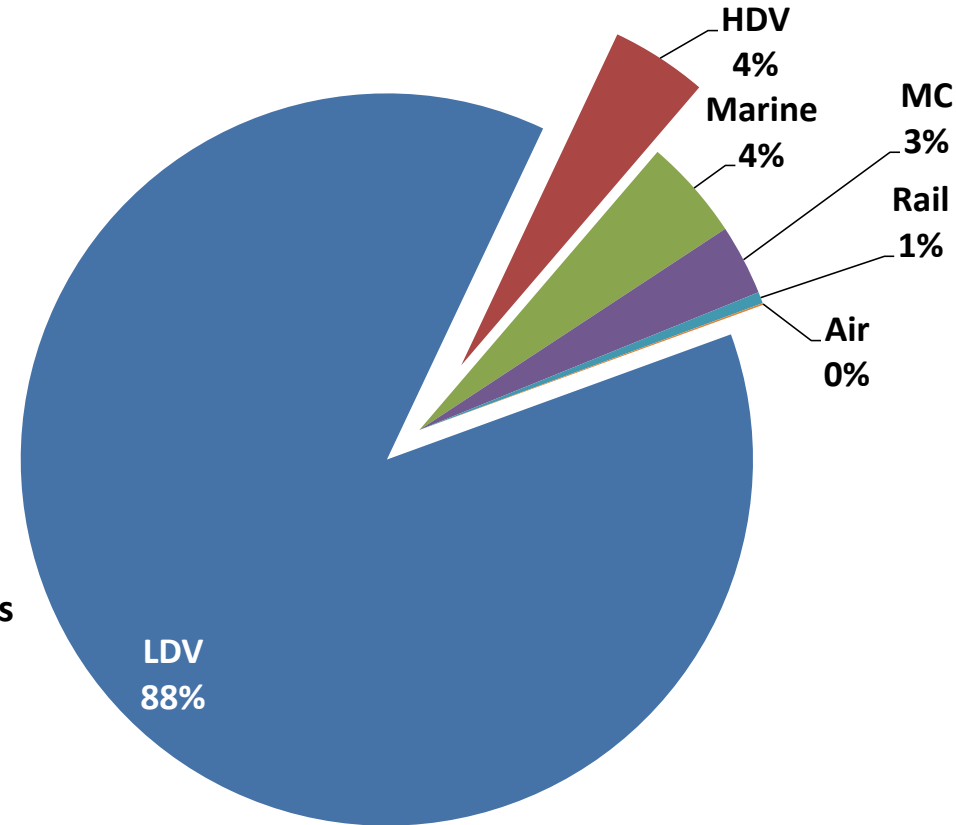
- 2014 US GHGs = 7.5 billion tons

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

2014 US GHGs by Transportation Sector



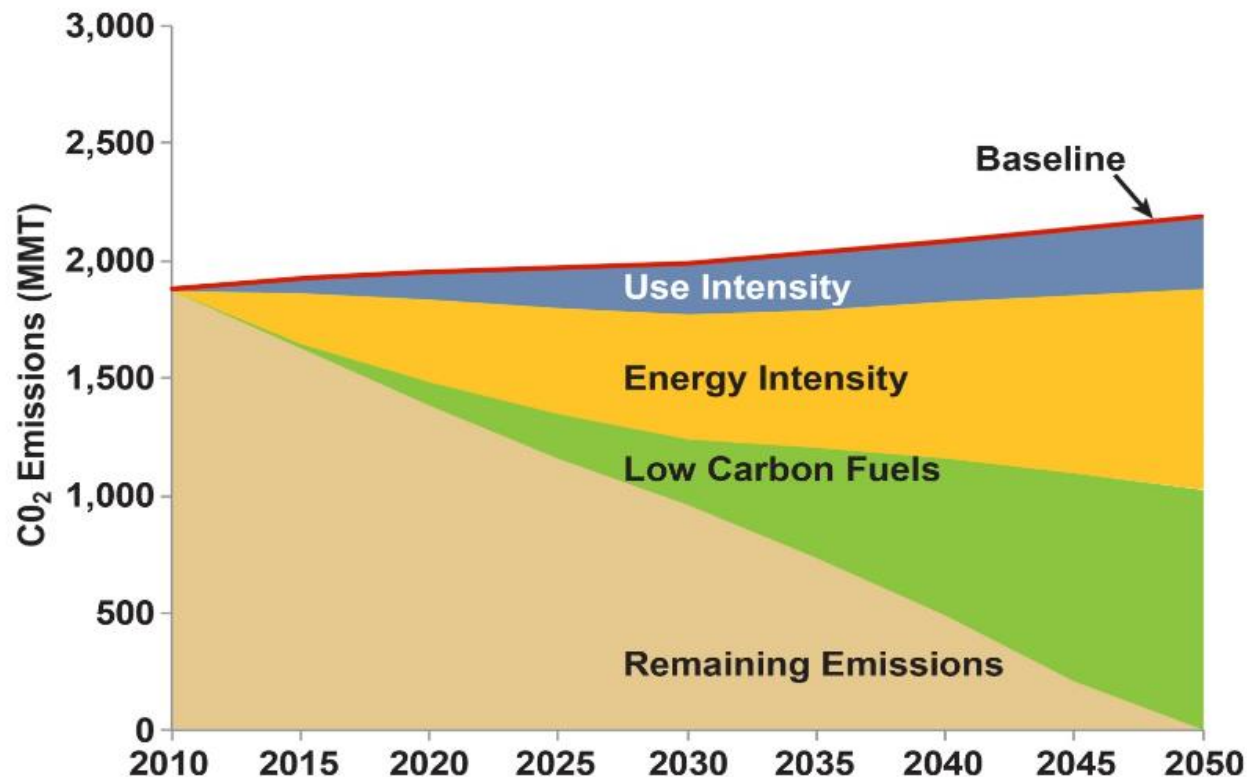
2013 US Vehicles by Type



- 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%

OBAMA ADMINISTRATION Fuel Economy Standards In the year 2025

The fleet-wide average will be **54.5 MPG**

Consumers will have saved **\$1.7 TRILLION** at the pump over the life of the program.

A family that purchases a new vehicle in 2025 will save **\$8,200** in fuel costs when compared with a similar vehicle in 2010.

Over the life of the program, the standards will:

- Save **12 billion barrels** of oil.
- Eliminate **6 billion metric tons** of carbon dioxide pollution.

This program, together with standards already put into place by this administration for Model Years 2011-2016, will result in significant cost savings for consumers at the pump, dramatically reduce oil consumption, cut pollution and create jobs.

Smartphone QR Code

WHITEHOUSE.GOV

Greenhouse Gas and Fuel Efficiency Standards for Heavy-Duty Trucks

Medium and heavy-duty vehicles = 23% of GHG emissions from transportation sector, but make up just 5% of vehicles on the road.

GHG emissions from heavy-duty vehicles are growing rapidly and will surpass cars by 2030.

Trucks haul 70% of freight in US.

The U.S. Environmental Protection Agency and the National Highway Safety Administration's proposed standards will **IMPROVE FUEL EFFICIENCY & CUT CARBON POLLUTION**

We'll save:

- 1 BILLION** metric tons of carbon pollution = carbon pollution from electricity and power from all homes in U.S. for 1 year.
- 75 BILLION** gallons of fuel
- Not to mention: **\$230 BILLION** IN BENEFITS TO SOCIETY

By 2027, fuel consumption and CO2 emissions lowered by up to:

- 24%**
- 16%**
- 16%**

TOTAL FUEL SAVINGS:

\$170 BILLION Over lifetime of vehicles

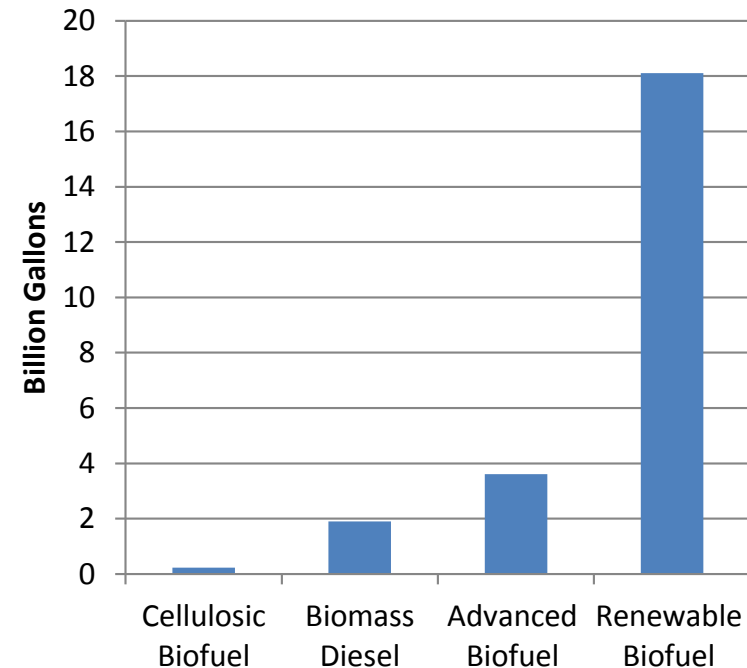
<http://www.epa.gov/otaq/climate/regs-heavy-duty.htm>
<http://www.nhtsa.gov/fuel-economy>

U.S. Department of Transportation
 U.S. Environmental Protection Agency

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

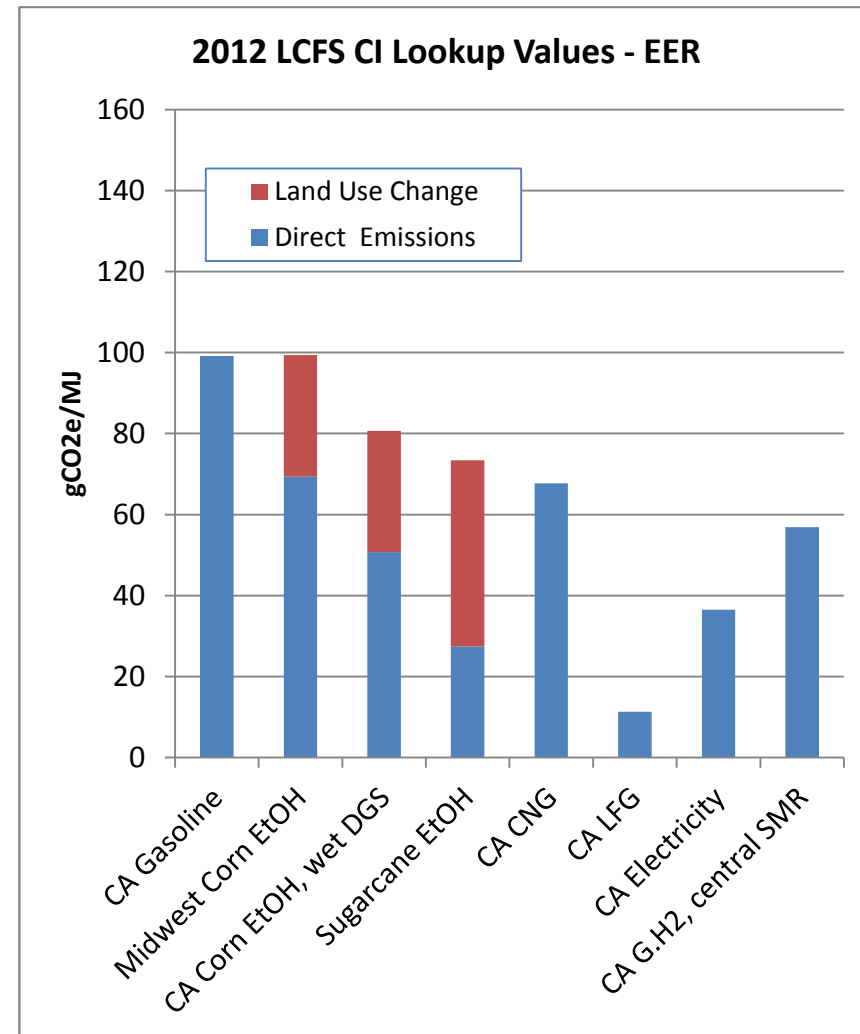
2016 Final Renewable Fuel Volumes



Renewable and Low-Carbon Fuel Life-Cycle GHG Standards

■ Low Carbon Fuel Standard - CARB

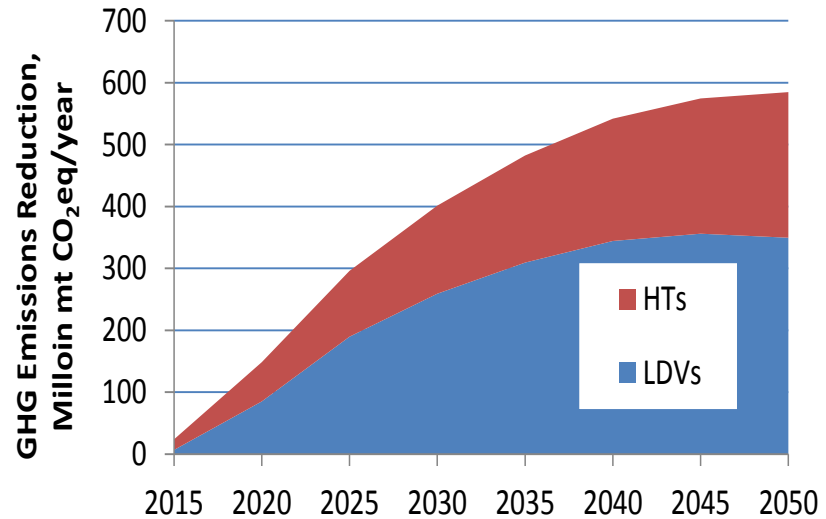
- 10% reduction in carbon intensity (CI) of CA fuel supply by 2020
 - Other PNW and NE states developing programs
- No specific volumes of any fuels required
- Fuel CI calculated via CA-GREET
- Fuel carbon intensity can be adjusted with vehicle efficiency (EER)
- 2016 CNG LCFS credit ~ \$0.40/GGE
- 2016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



Other GHG Regulations and Programs

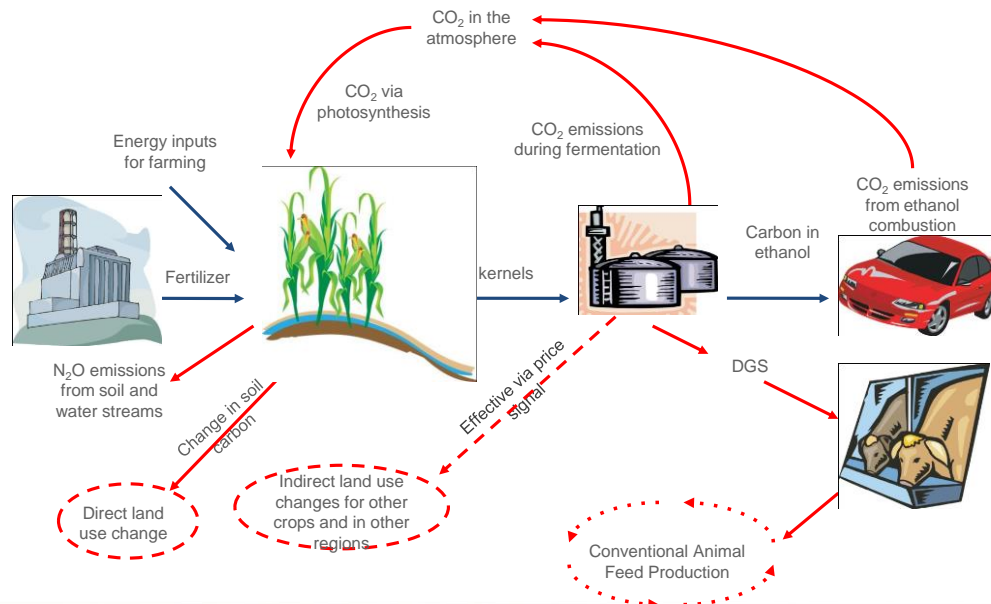
- **Clean Power Plan - EPA (pending)**
 - Reduce electricity GHGs 32% from 2005 levels by 2030
- **Methane Challenge Program - EPA**
 - Voluntary program to reduce CH₄ emissions from the oil and gas sector by 40-45% from 2012 levels by 2025
- **Research, development, demonstration & deployment – DOE**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

VTO Program Success - Projected GHG Reductions

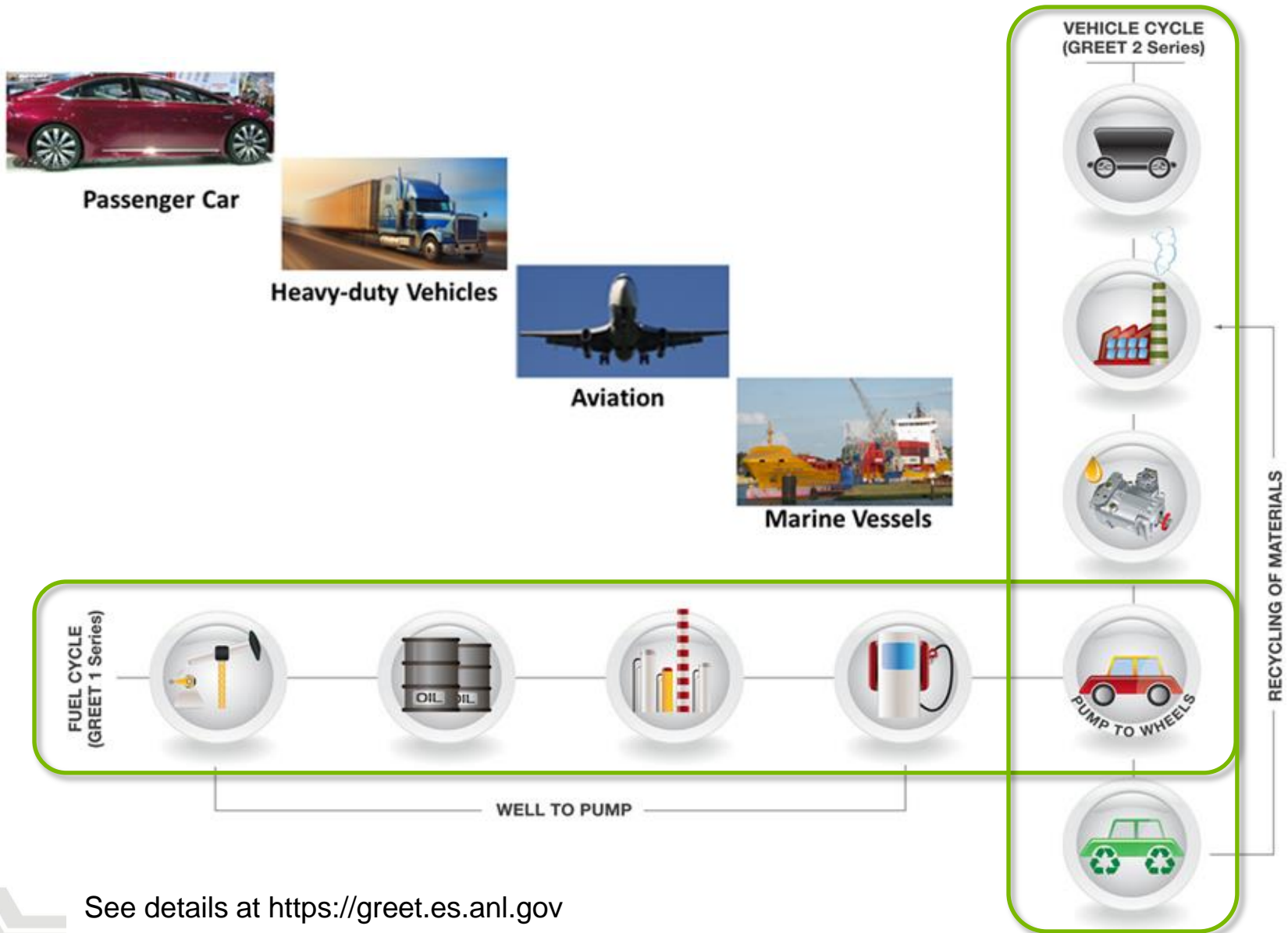


Life-Cycle Analysis for Vehicle/Fuel Systems Has Evolved in the Past 30 Years

- 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

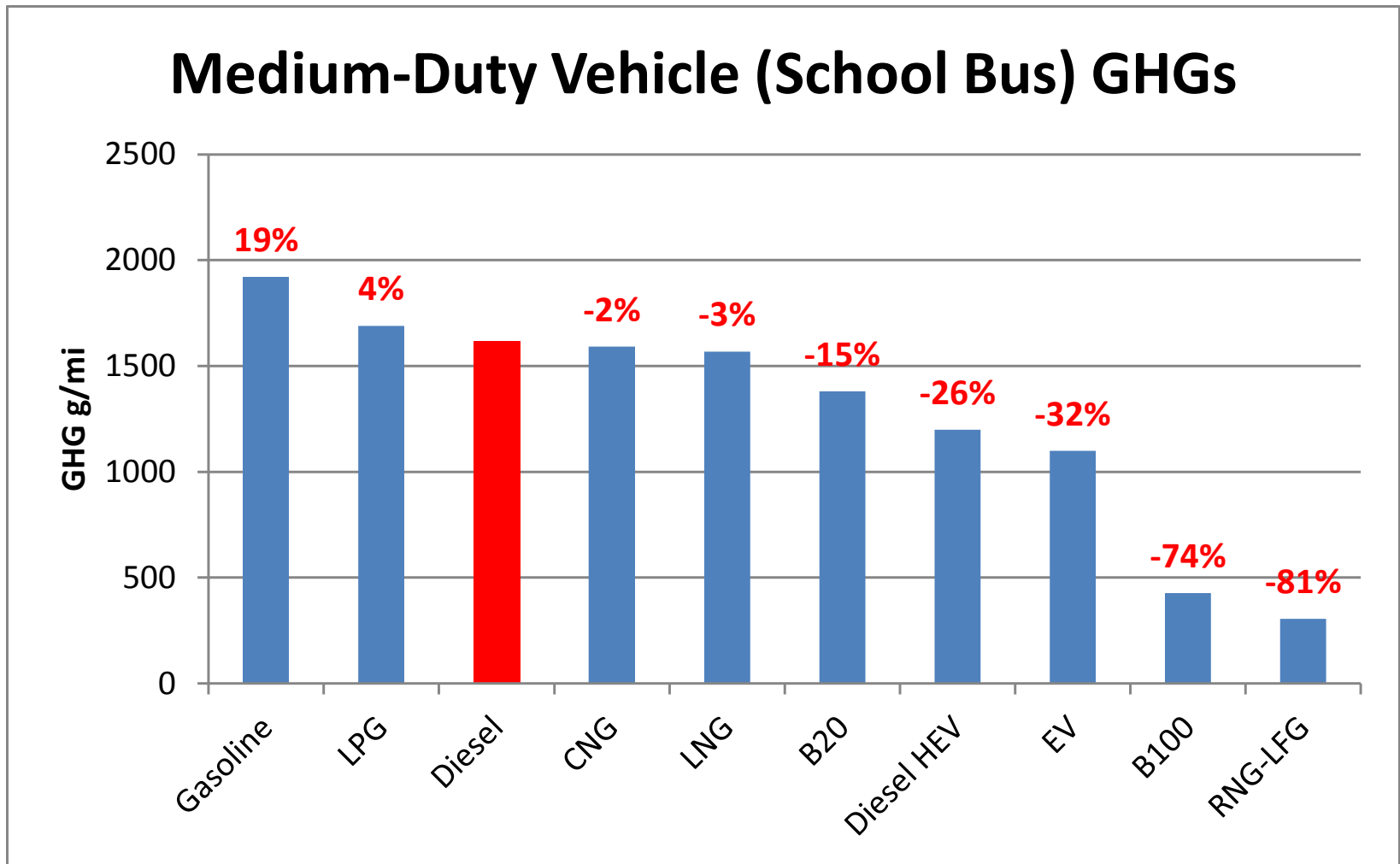


The GREET Model at Argonne National Laboratory



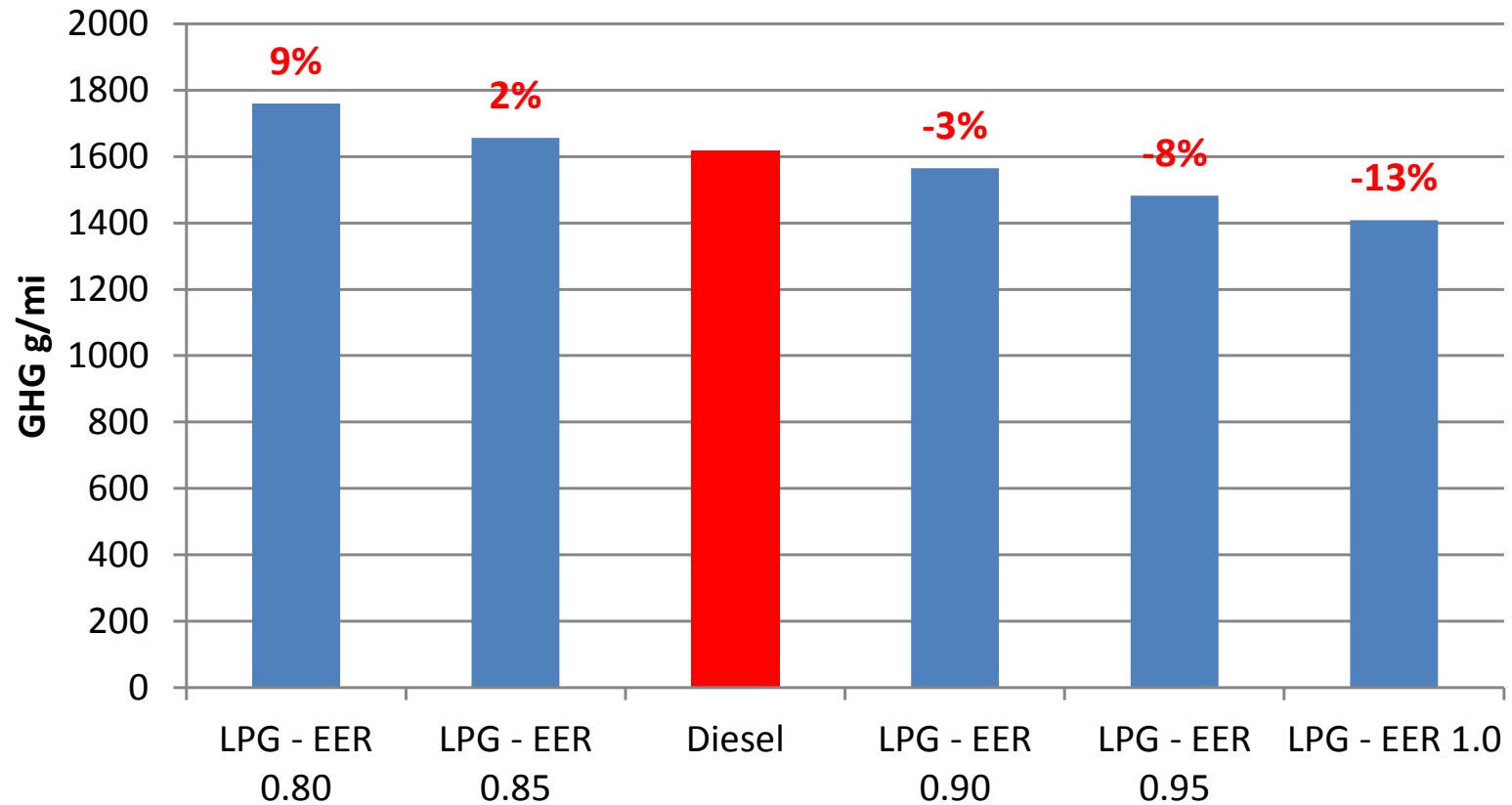
See details at <https://greet.es.anl.gov>

Life-Cycle GHGs Depend on Both CI and Fuel Efficiency



Fuel Economy Impacts of MD/HD LPG GHGs vs Diesel

Medium-Duty Vehicle (School Bus) GHGs

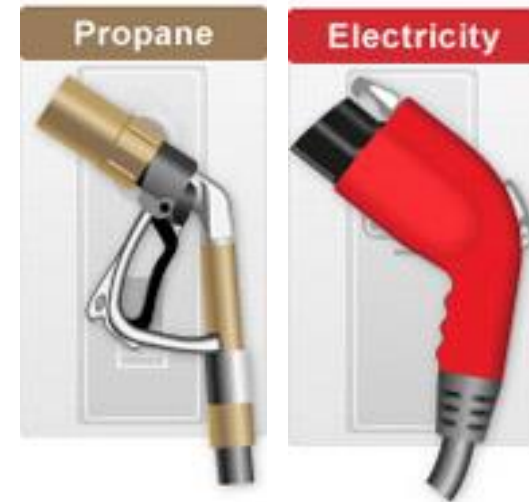


AFLEET Tool Update



“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, H₂, 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**



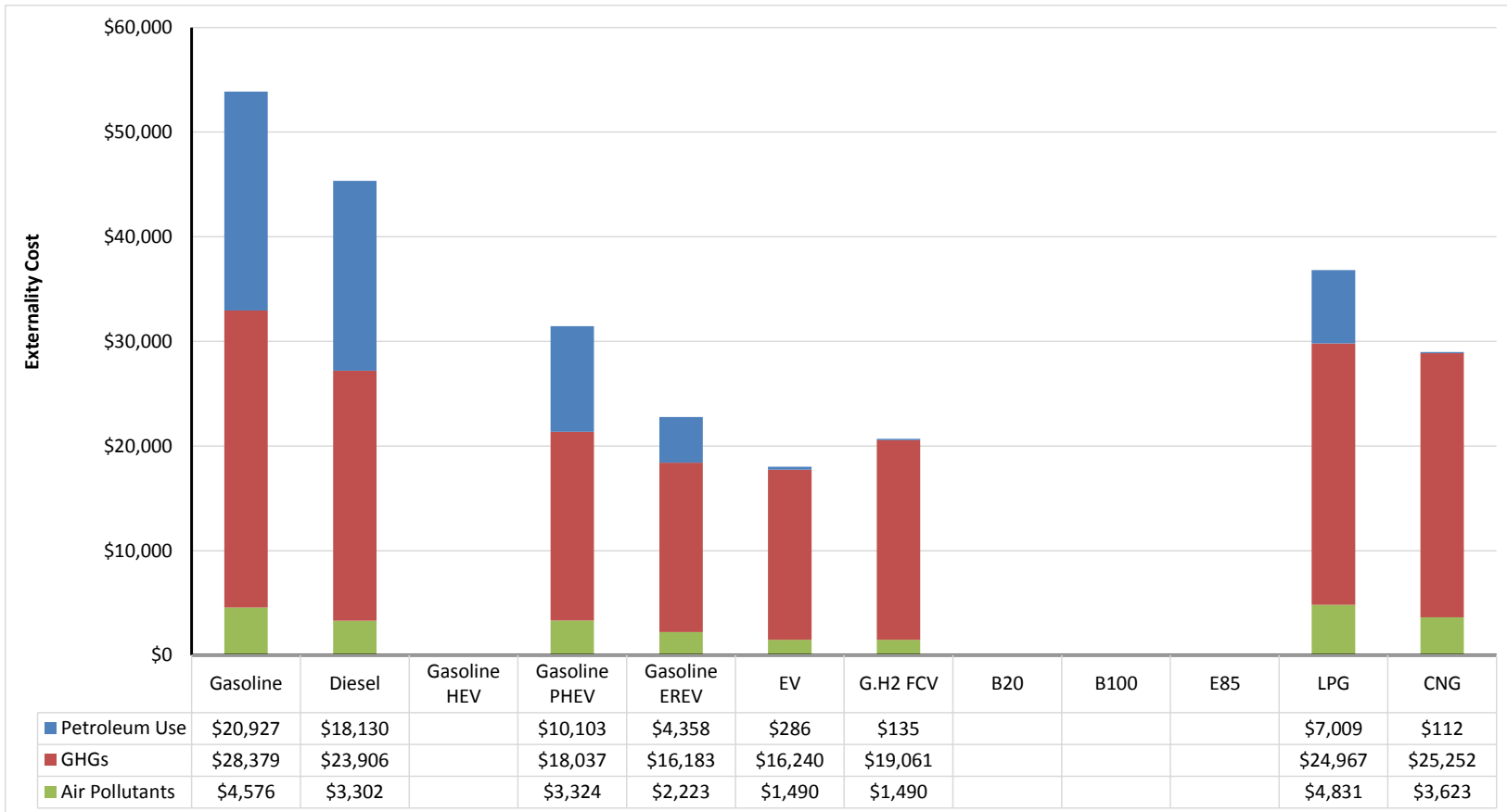
AFLEET Tool 2016 Updates - Vehicle & Emission Data

- 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



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



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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