# Alternative Fuel and Conventional Vehicle Greenhouse Gas Emissions and AFLEET Update

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Clean Cities Webinar
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# Agenda

- **Transportation Greenhouse Gas Emissions**
- **AFLEET Update**
- **AFLEET Demo**
  - Simple Payback and TCO Calculators

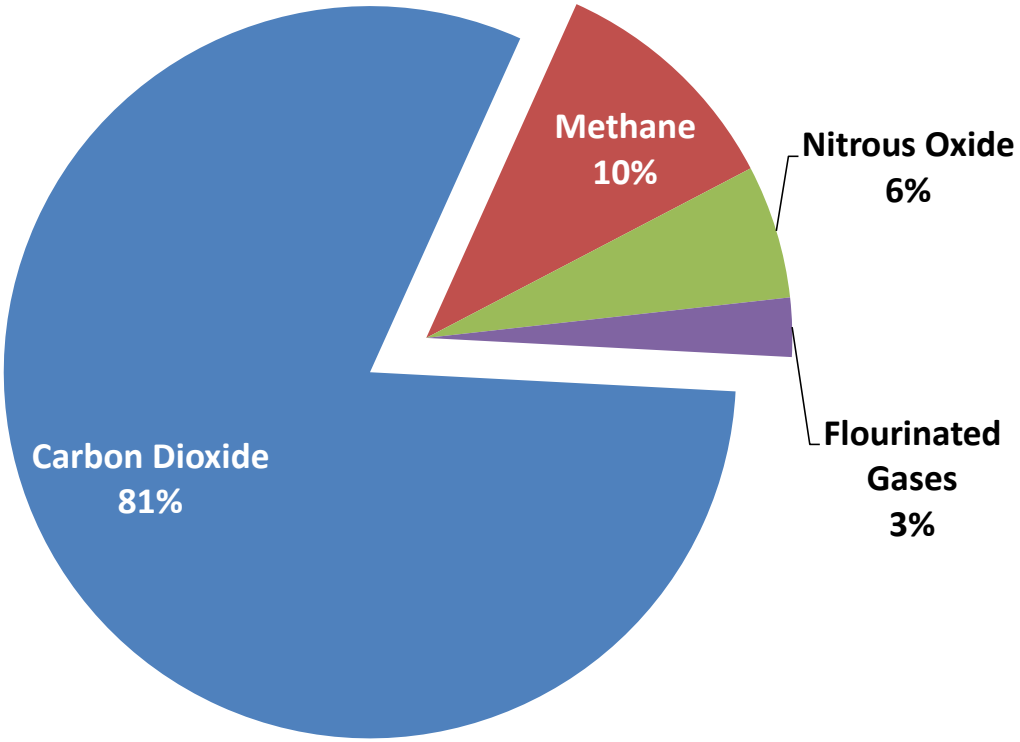
# Transportation Greenhouse Gas Emissions

# Key Greenhouse Gas Emissions Impacting Climate Change

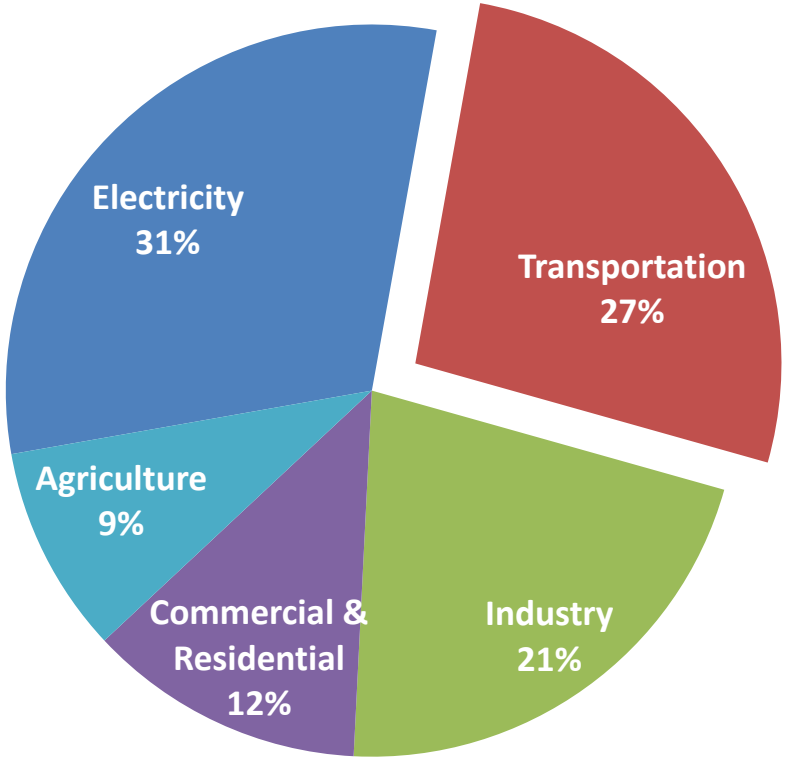
- **Carbon dioxide ($CO_2$)**
  - Produced via fossil- & bio-fuel combustion
  - Sequestered by plants as part of biological carbon
  - GWP = 1
- **Methane ($CH_4$)**
  - Emitted via production, transport & use of fossil fuels
  - Livestock and decay of organic waste in landfills
  - GWP = 30
- **Nitrous 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**



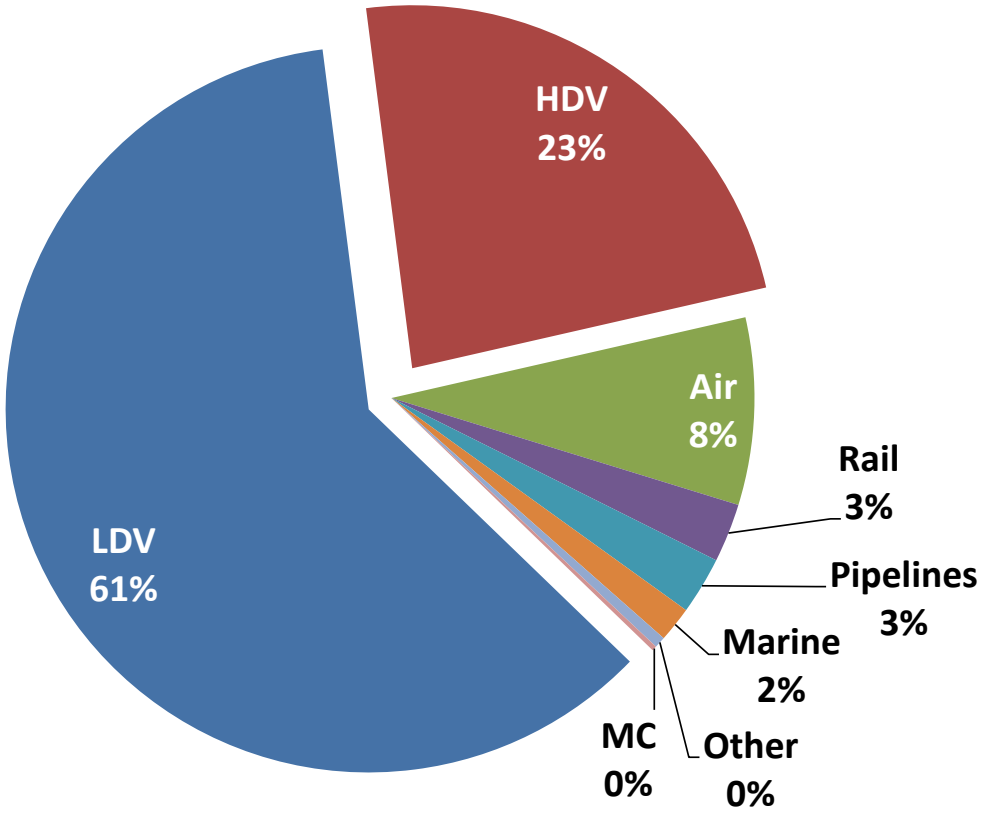

**2014 US GHGs by Sector**



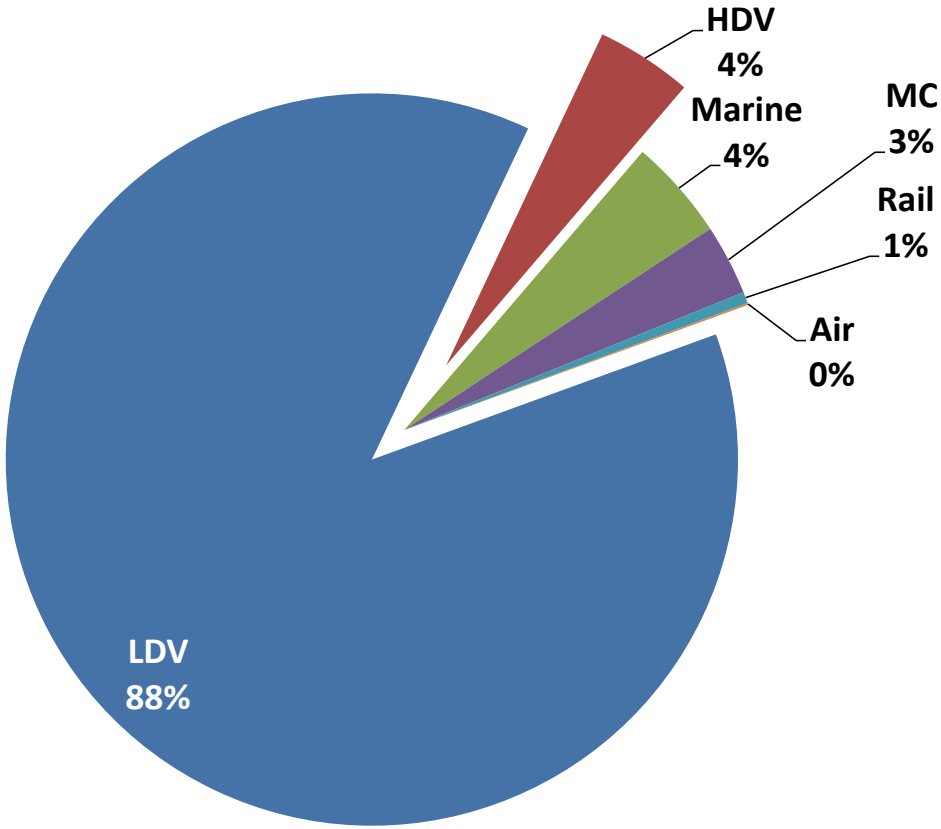

- **2014 US GHGs = 7.5 billion tons**

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

**2014 US GHGs by Transportation Sector**



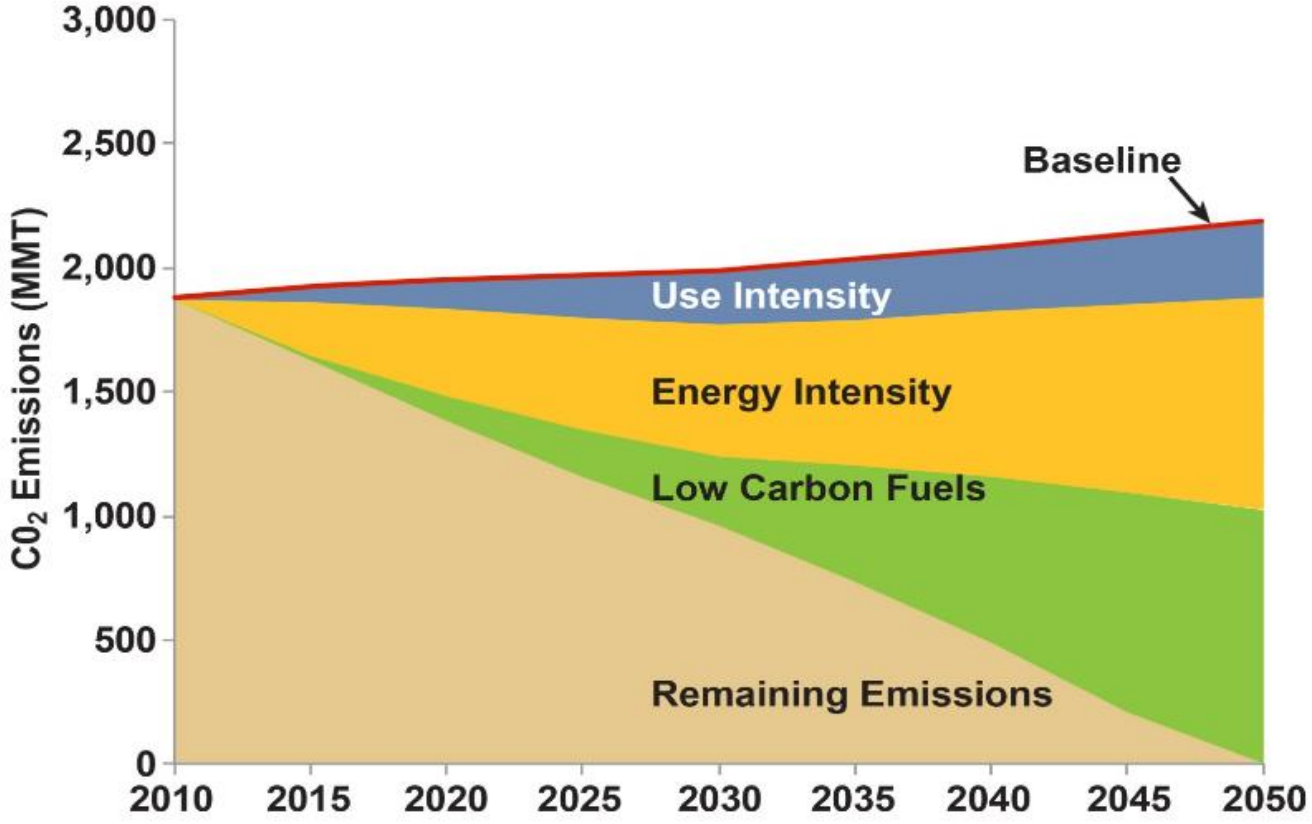

**2013 US Vehicles by Type**




- 2014 US Transportation GHGs = 2 billion tons

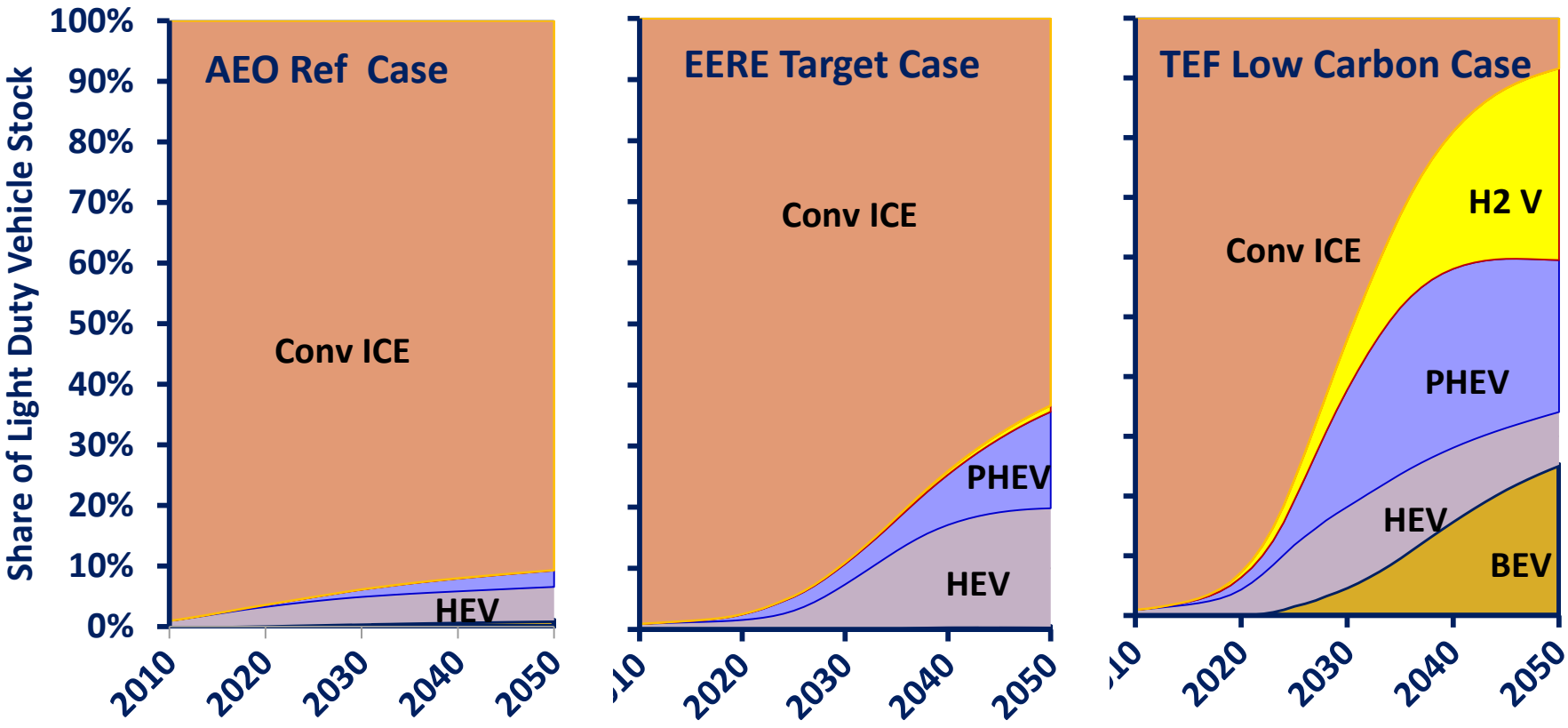
# Major Administration U.S. Transportation GHG Goals

- **Reduce GHG emissions by 17% by 2020, 26-28% by 2025 and 83% by 2050 from 2005 baseline**



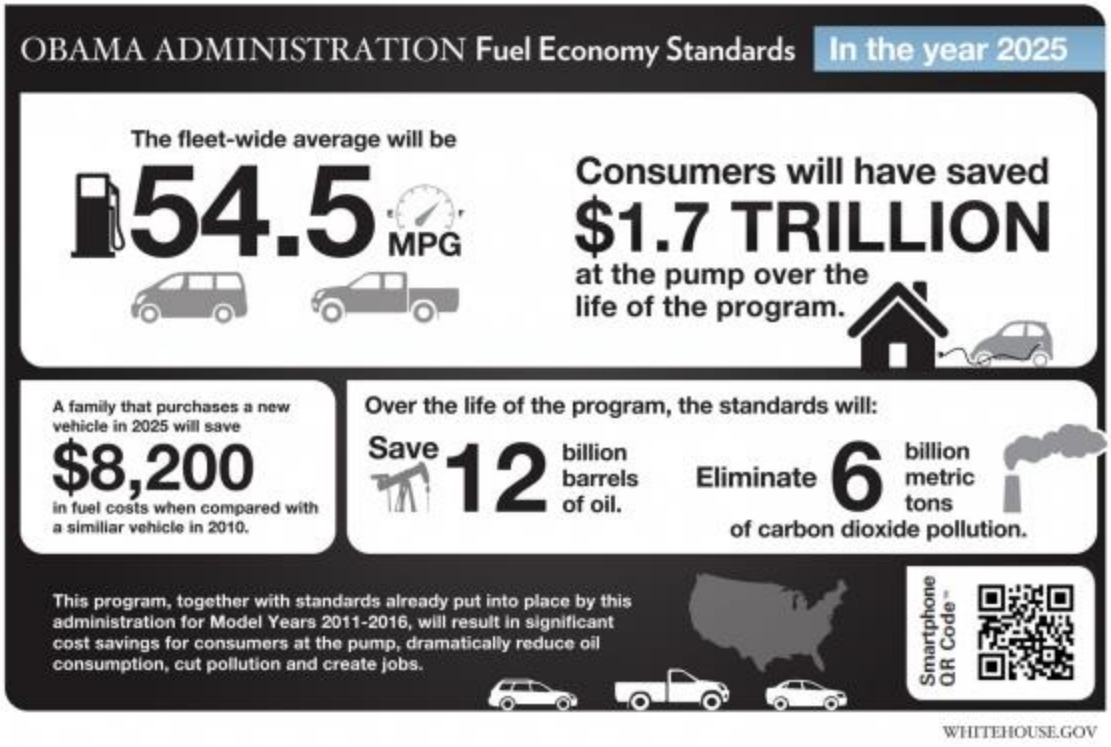
# Uptake of Advanced Vehicle Technologies and Low Carbon Fuels Will Strongly Impact Future Transportation GHGs

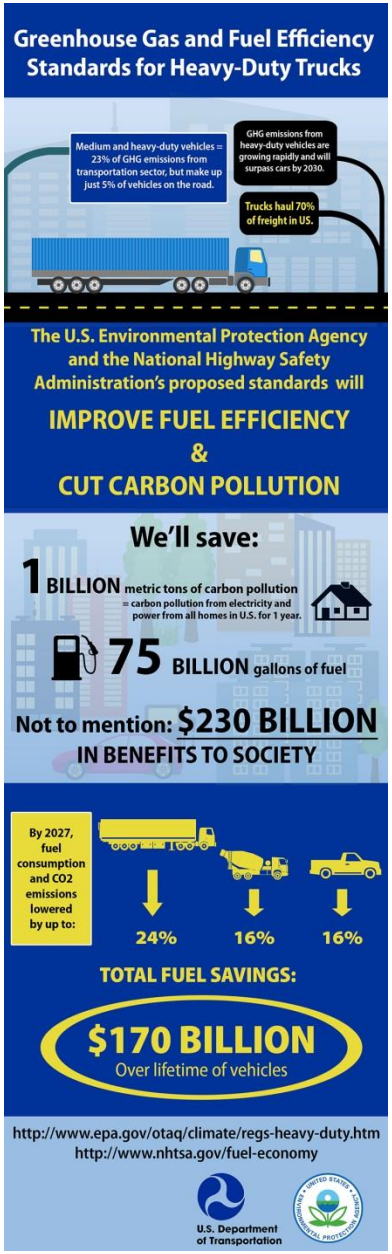
**2050 GHGs: 13% increase** | **18% reduction** | **84% reduction**



# Vehicle Tailpipe GHG Standards

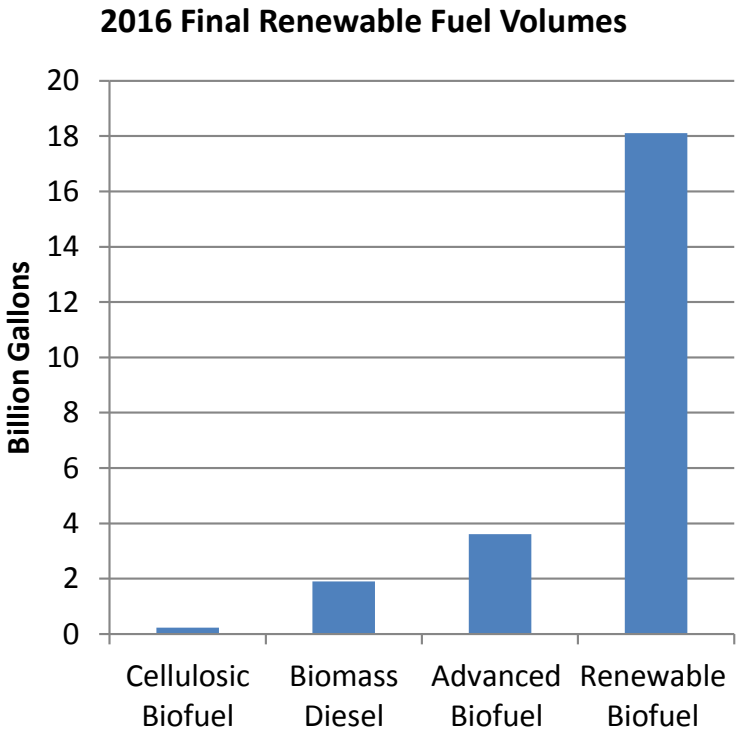
- **Light-Duty Reductions - EPA**
  - Phase 1 - MY2012->2016 = 15%
  - Phase 2 = MY2017->2025 = 33%



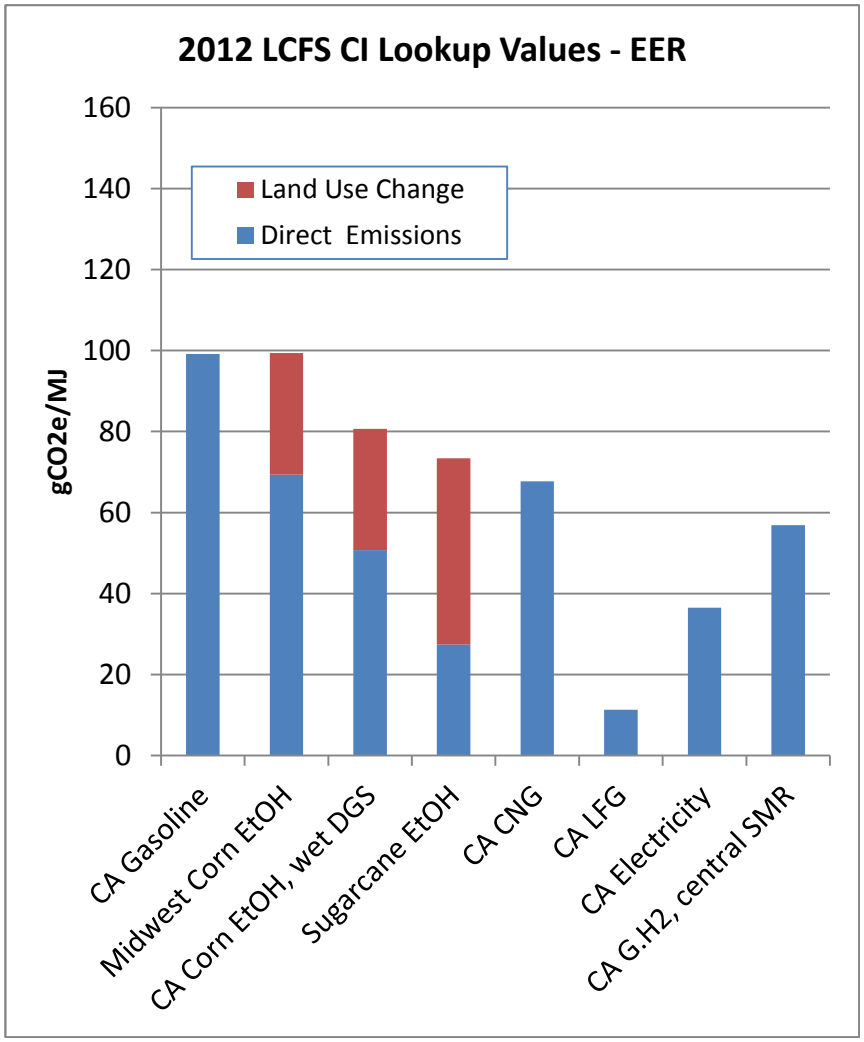
# Renewable and Low-Carbon Fuel Life-Cycle GHG Standards

- **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%



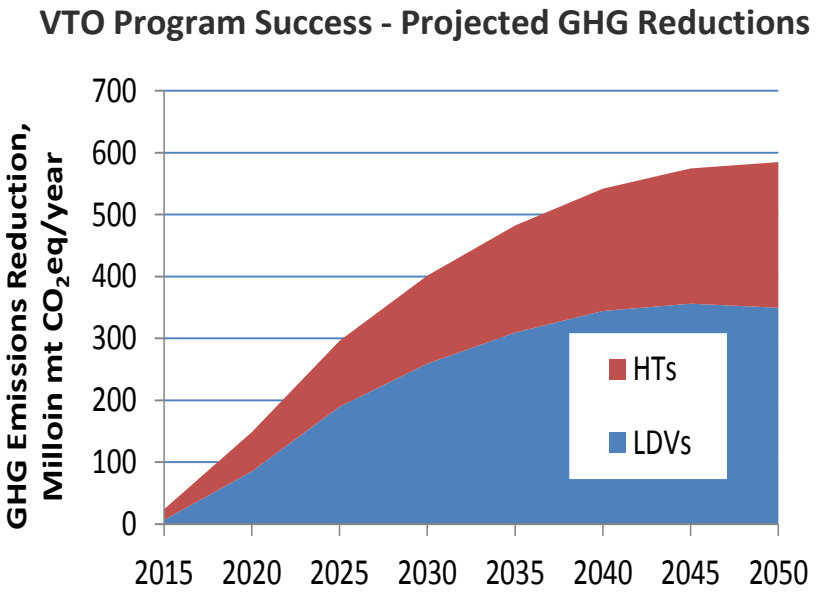
# Renewable and Low-Carbon Fuel Life-Cycle GHG Standards

- **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)
    - CA electricity = 124 gCO2e/MJ
    - EV = 3.4 EER
    - 124/3.4 = 36.5 g/CO2e final value



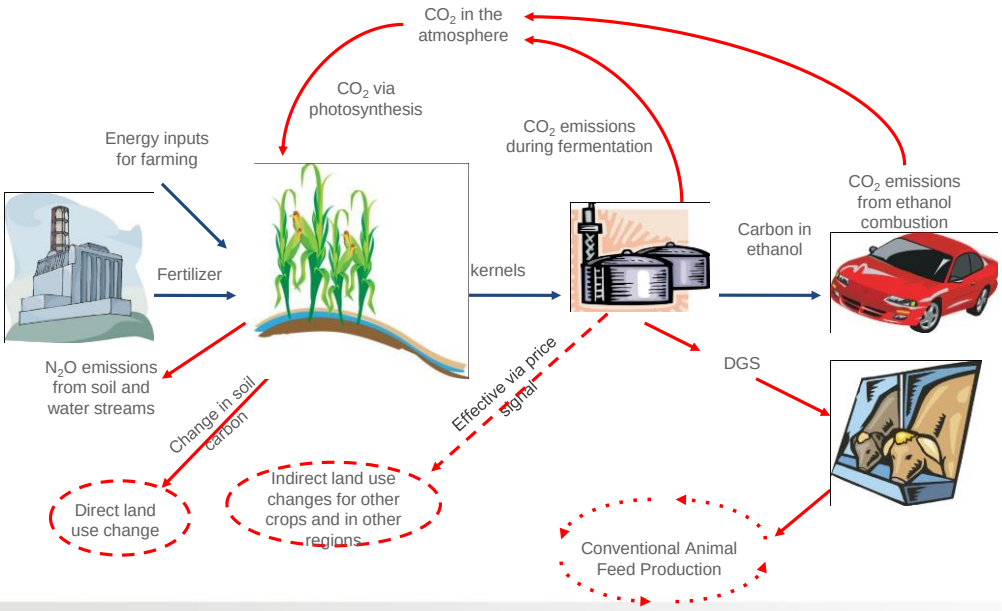
# Other GHG Regulations and Programs

- **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

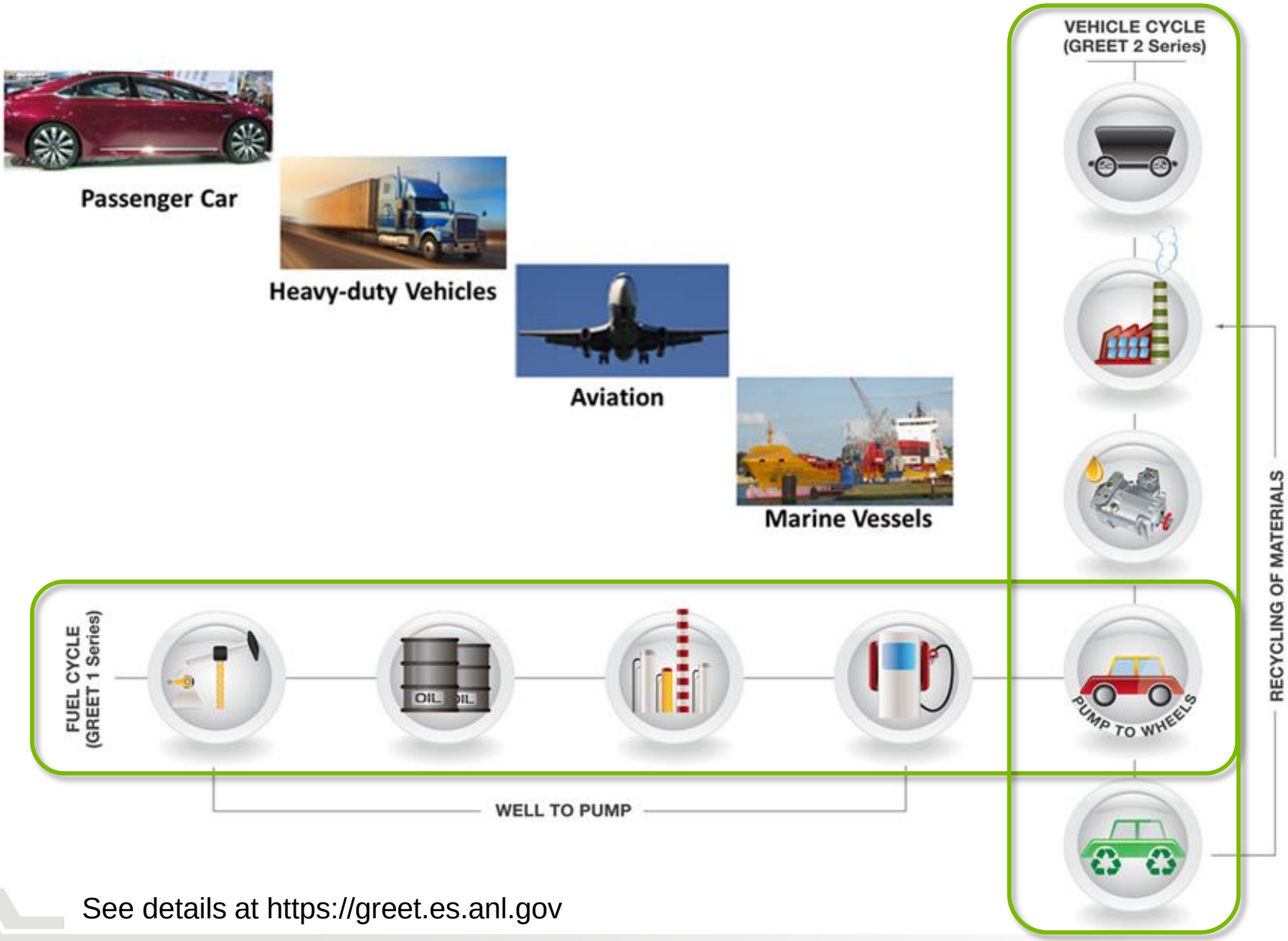


# Life-Cycle Analysis for Vehicle/Fuel Systems Has Evolved in the Past 30 Years

- **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

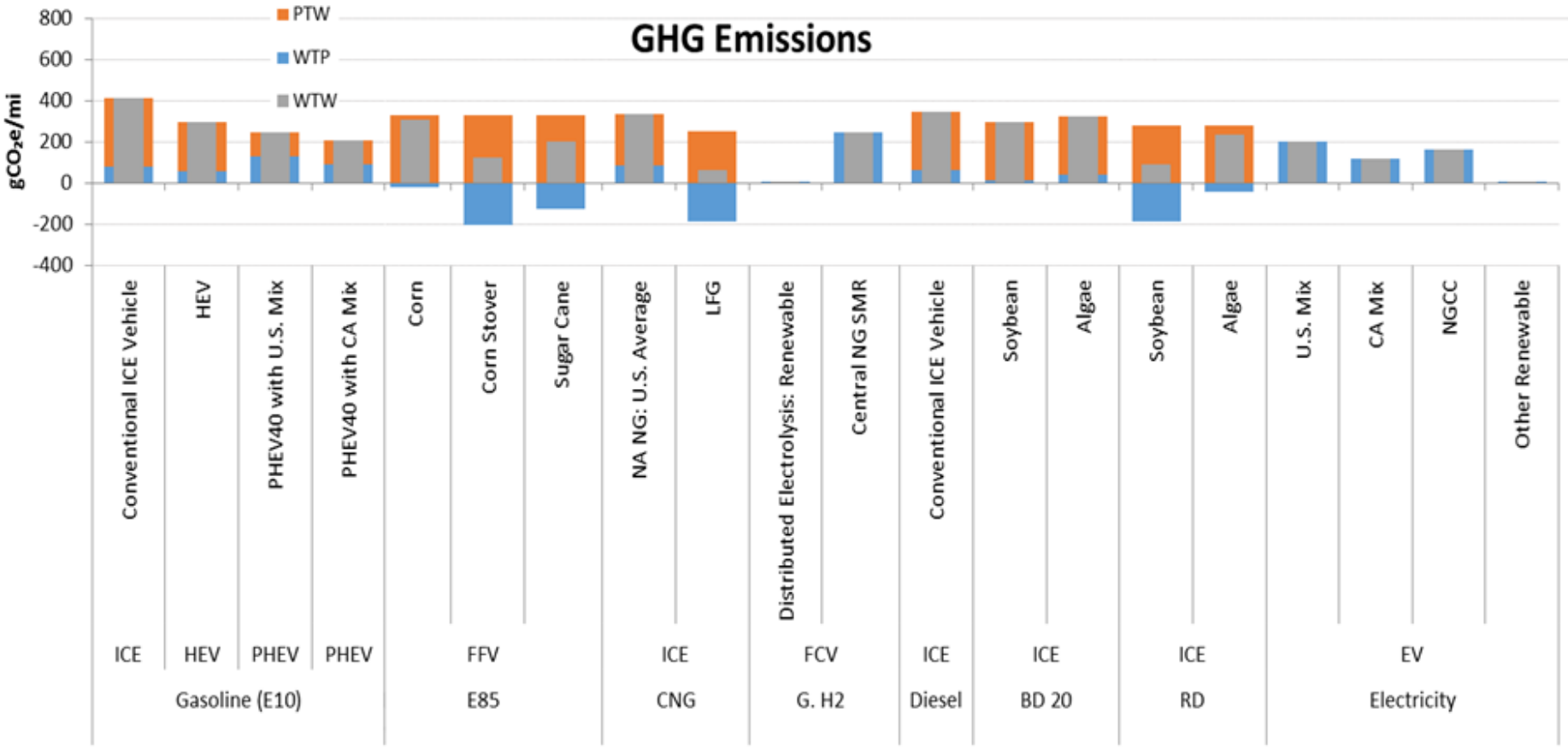


# The GREET Model at Argonne National Laboratory



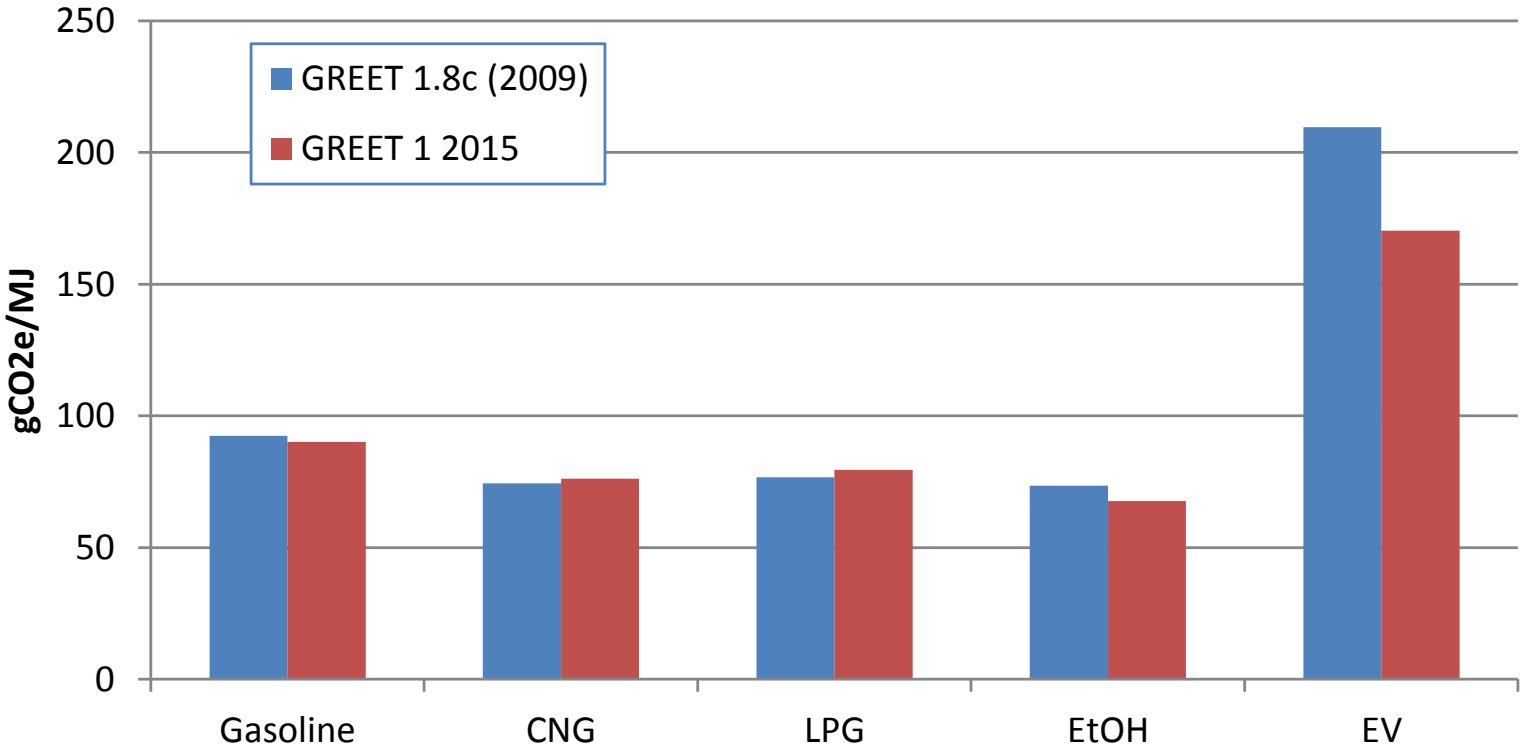

See details at https://greet.es.anl.gov

# GREET 2014 Sample GHG Results Show Wide Variation Depending on Vehicle, Fuel, and Feedstock



# GREET is Updated Annually w/ Latest Data & Research Results

## Comparison of CI of Selected Fuels from GREET 2009 & 2015 Versions



# 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

- **AFLEET Tool 2016 & its user manual will be released next week: http://greet.es.anl.gov/afleet**

# AFLEET Tool 2016 Updates - Fuel Prices

- Added private station pricing from Clean Cities Alternative Fuel Price Report
- Public & private station pricing are now state-based
- Can investigate a range of fuel prices for simple payback

| Refueling Information | | | |
|---|---|---|---|
| Fueling Type | Private Station | For infrastructure costs, go to 'Payback' sheet | |
| Fuel Price Sensitivity | No | To enter fuel price range, go to 'Payback' sheet | |
| **Fuel and DEF Price** | | | |
| | | **Public Station** | **Private Station** |
| | **Fuel Unit** | **($/Fuel Unit)** | |
| Gasoline | gasoline gallon | $3.01 | $2.84 |
| Diesel | diesel gallon | $3.04 | $3.03 |
| Electricity | kWh | $0.16 | $0.16 |
| G.H2 | hydrogen kg | $20.29 | $6.99 |
| B20 | B20 gallon | $2.92 | $2.70 |
| B100 | B100 gallon | $3.94 | $4.41 |
| E85 | E85 gallon | $2.59 | $2.56 |
| Propane | LPG gallon | $3.01 | $2.63 |
| CNG | CNG GGE | $2.43 | $1.96 |
| LNG | LNG gallon | $2.86 | $2.11 |
| Diesel Exhaust Fluid (DEF) | DEF gallon | $2.80 | $2.80 |

# AFLEET Tool 2016 Updates - Infrastructure Costs

- **Added refueling station and EVSE infrastructure construction, operation, and maintenance costs**
  - Can estimate other infrastructure-related costs such as public station out-of-route mileage and fueling labor costs

**Simple Payback Calculator**

| | Gasoline | Diesel | Gasoline EREV | EV | G.H2 FCV | LPG | CNG |
|---|---|---|---|---|---|---|---|
| **Infrastructure Inputs** | | | | | | | |
| Station/EVSE Type | New Private | New Private | Level 1 | Level 2 - Home | New Private | New Private | New Private: Time-Fill |
| Number of stations/EVSEs | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Total Refueling Station/EVSE Cost | $91,332 | $91,332 | $720 | $1,200 | $1,819,569 | $26,415 | $204,423 |
| Total Incentive | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| Maintenance Depot Cost | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| Annual Private Station/EVSE Operation & Maintenance (O&M) Costs ($/yr) | $5,937 | $5,937 | $0 | $0 | $110,994 | $1,717 | $13,287 |
| Default Refueling Station/EVSE Cost | $91,332 | $91,332 | $720 | $1,200 | $1,819,569 | $26,415 | $204,423 |
| Default Annual Private Station/EVSE O&M Costs ($/yr) | $5,937 | $5,937 | $0 | $0 | $110,994 | $1,717 | $13,287 |
| Annual Private Fueling Labor & Misc. Costs ($/yr) | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| **Public Out of Route Mileage, Labor & Misc. Costs** | | | | | | | |
| LD Annual Out of Route Mileage To Public Station | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LD Out of Route Vehicle Speed (miles/hr) | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| LD Labor Rate ($/hr) | $25 | $25 | $25 | $25 | $25 | $25 | $25 |
| LD Annual Out of Route Labor Costs ($/yr) | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| LD Public Fueling Labor & Misc. Costs ($/yr) | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| **Private Out of Route Mileage, Labor & Misc. Costs** | | | | | | | |
| HD Annual Out of Route Mileage To Public Station | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| HD Out of Route Vehicle Speed (miles/hr) | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| HD Labor Rate ($/hr) | $25 | $25 | $25 | $25 | $25 | $25 | $25 |
| HD Annual Out of Route Labor Costs ($/yr) | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| HD Public Fueling Labor & Misc. Costs ($/yr) | $0 | $0 | $0 | $0 | $0 | $0 | $0 |

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

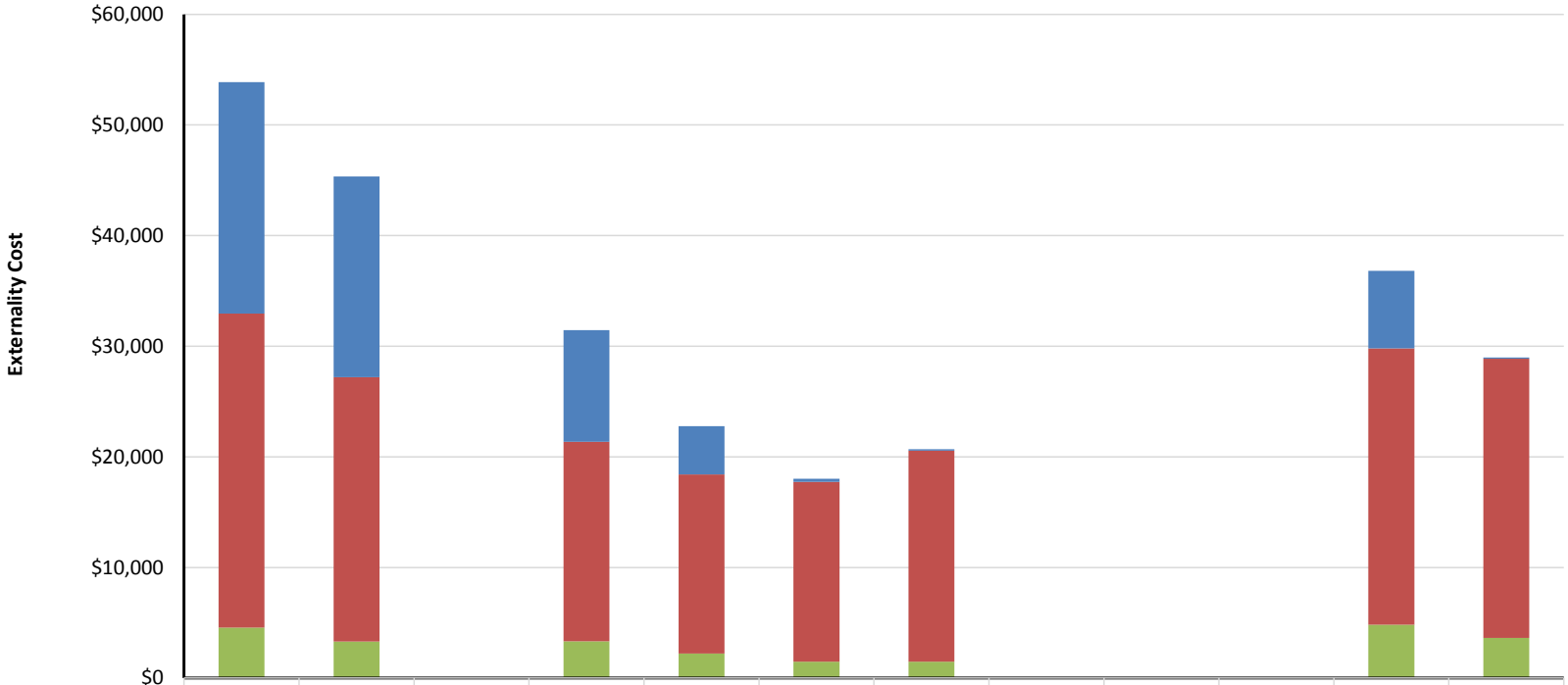
# AFLEET Tool 2016 Updates - Vehicle & Emission Data

- **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
  - Includes FCVs
  - Update includes RNG - wastewater treatment, H2 SMR & H2 electrolysis pathways
- **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 |

# 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, County (for externalities) & 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 | CALIFORNIA | | | |
| County | LOS ANGELES | | | |
| **Heavy-Duty Vehicle Information** | | | | |
| Vehicle Type | Refuse Truck | | | |
| **Heavy-Duty Fuel Type** | **Number of Heavy-Duty Vehicles** | **Annual Vehicle Mileage** | **Fuel Economy (MPDGE)** | **Purchase Price ($/Vehicle)** |
| Gasoline | 0 | 0 | 1.4 | $0 |
| Diesel | 10 | 23,400 | 1.7 | $210,000 |
| All-Electric Vehicle (EV) | 10 | 23,400 | 4.8 | $670,000 |
| Gaseous Hydrogen (G.H2) Fuel Cell Vehicle (FCV) | 0 | 0 | 2.9 | $0 |
| Diesel Hybrid Electric Vehicle (HEV) | 10 | 23,400 | 2.2 | $260,000 |
| Diesel Hydraulic Hybrid (HHV) | 10 | 23,400 | 2.2 | $250,000 |
| Biodiesel (B20) | 10 | 23,400 | 1.7 | $210,000 |
| Biodiesel (B100) | 10 | 23,400 | 1.7 | $210,000 |
| Ethanol (E85) | 0 | 0 | 1.4 | $0 |
| Propane (LPG) | 0 | 0 | 1.4 | $0 |
| Compressed Natural Gas (CNG) | 10 | 23,400 | 1.5 | $260,000 |
| Liquefied Natural Gas (LNG) | 0 | 23,400 | 1.5 | $250,000 |
| LNG / Diesel Pilot Ignition | 0 | 0 | 1.6 | $0 |

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

# AFLEET Tutorial - Simple Payback and TCO Calculators

- **2nd step: enter key fuel price inputs on "Inputs" sheet**
  - Choose either public or private station fuel pricing (via drop-down)
    - Results based on state level AFPR data
  - 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 | For infrastructure costs, go to 'Payback' sheet |
| Fuel Price Sensitivity | No | To enter fuel price range, go to 'Payback' sheet |

| **Fuel and DEF Price** | | | |
|---|---|---|---|
| | | **Public Station** | **Private Station** |
| | **Fuel Unit** | **($/Fuel Unit)** | |
| Gasoline | gasoline gallon | $3.01 | $2.84 |
| Diesel | diesel gallon | $3.04 | $3.03 |
| Electricity | kWh | $0.16 | $0.16 |
| G.H2 | hydrogen kg | $20.29 | $6.99 |
| B20 | B20 gallon | $2.92 | $2.70 |
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| Propane | LPG gallon | $3.01 | $2.63 |
| CNG | CNG GGE | $2.43 | $1.96 |
| LNG | LNG gallon | $2.86 | $2.11 |
| Diesel Exhaust Fluid (DEF) | DEF gallon | $2.80 | $2.80 |

# AFLEET Tutorial - Simple Payback and TCO Calculators

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

**Total Cost of Ownership Inputs**

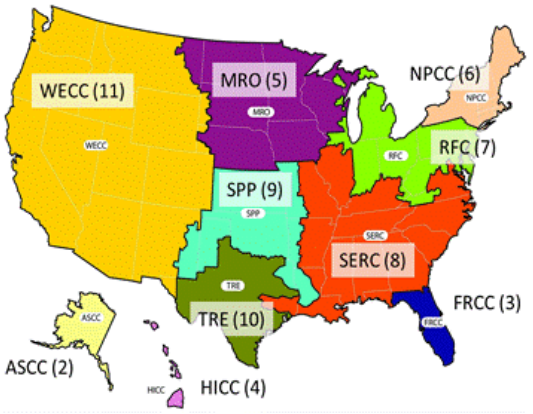
| | | | |
|---|---|---|---|
| **Light-Duty Vehicle Information** | | | |
| Years of Planned Ownership | years | 15 | |
| **Heavy-Duty Vehicle Information** | | | |
| Years of Planned Ownership | years | 15 | |
| **Infrastructure Information** | | | |
| Years of Planned Ownership | years | 15 | |
| **Financial Assumptions** | | | |
| | | **Vehicles** | **Infrastructure** |
| Loan | yes/no | No | No |
| Loan Term | years | 5 | 5 |
| Interest Rate | % | 3.37% | 3.37% |
| Percent Down Payment | % | 0.00% | 0.00% |
| Discount Factor | % | 0.83% | |

# AFLEET Tutorial - Simple Payback and TCO Calculators

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

**Fuel Production Assumptions**

| | | | |
|---|---|---|---|
| Biodiesel Feedstock Source | 1 - Soy<br>2 - Algae | 1 | |
| Ethanol Feedstock Source | 1 - Corn<br>2 - Switchgrass | 1 | |
| CNG Feedstock Source | 1 - North American NG<br>2 - Renewable NG - Wastewater Treatment<br>3 - Landfill Gas | 1 | |
| LNG Feedstock Source | 1 - North American NG<br>2 - Renewable NG - Wastewater Treatment<br>3 - Landfill Gas | 1 | |
| North American NG Feedstock Source | | Conventional<br>66% | Shale<br>34% |
| LPG Feedstock Source | | NG<br>69% | Petroleum<br>31% |
| Source of Electricity for PHEVs, EVs, and FCVs (Electrolysis) | | | |
| | 1 - Average U.S. Mix | 1 | |
| | 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) | | |



# AFLEET Tutorial - Simple Payback and TCO Calculators

- **5th step: if examining PHEV or EREV, enter additional 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 | Light Commercial Truck | | | | |
| Number of LDVs | 4 | 0 | 0 | 0 | 0 |
| Annual Mileage | 23,500 | 24,000 | 0 | 0 | 0 |
| Fuel Economy (MPGGE) | 13.0 | 15.6 | 16.9 | 17.9 | 13.3 |
| Fuel Consumption (GGE/100mi) | 7.7 | 6.4 | 5.9 | 5.6 | 7.5 |
| CD Electricity Use (kWh/100mi) | | | | 33.0 | 74.0 |
| CD Electricity Use (GGE/100mi) | | | | 1.0 | 2.2 |
| CD Gasoline Use (GGE/100mi) | | | | 3.4 | 0.0 |
| PHEV CD Range (miles) | | | | 10.9 | 33.1 |
| Charges/day | | | | 1.0 | 1.0 |
| Days driven/week | | | | 5 | 5 |
| Share of CD miles | | | | #DIV/0! | #DIV/0! |
| Purchase Price ($/vehicle) | $30,500 | $38,000 | $0 | $0 | $0 |
| Incentive ($/vehicle) | $0 | $0 | $0 | $0 | $0 |
| Maintenance & Repair ($/mile) | $0.18 | $0.29 | $0.18 | $0.18 | $0.18 |

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

# AFLEET Tutorial - Simple Payback and TCO Calculators

- **6th 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 and TCO Calculators

- **7th 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
    - Can also enter OOR mileage, labor costs, etc.

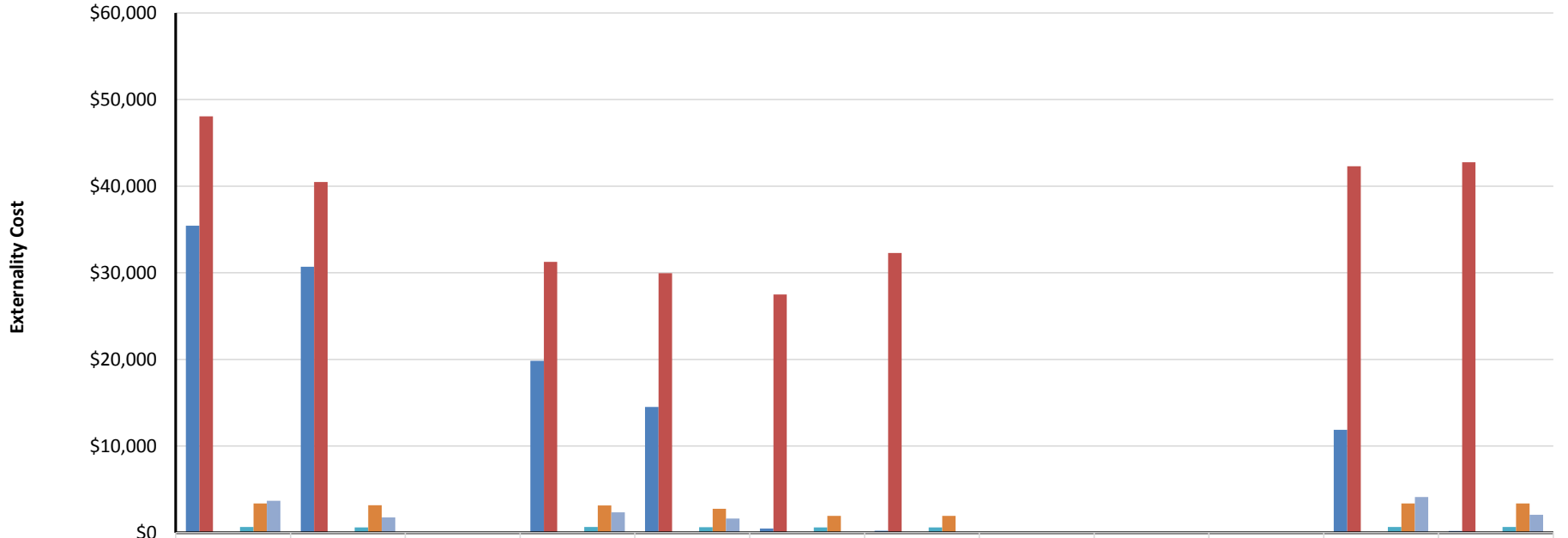
**Simple Payback Calculator**

| | Gasoline | Diesel | Gasoline EREV | EV | G.H2 FCV | LPG | CNG |
|---|---|---|---|---|---|---|---|
| **Infrastructure Inputs** | | | | | | | |
| Station/EVSE Type | New Private | New Private | Level 1 | Level 2 - Home | New Private | New Private | New Private: Time-Fill |
| Number of stations/EVSEs | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Total Refueling Station/EVSE Cost | $91,332 | $91,332 | $720 | $1,200 | $1,819,569 | $26,415 | $204,423 |
| Total Incentive | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| Maintenance Depot Cost | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| Annual Private Station/EVSE Operation & Maintenance (O&M) Costs ($/yr) | $5,937 | $5,937 | $0 | $0 | $110,994 | $1,717 | $13,287 |
| Default Refueling Station/EVSE Cost | $91,332 | $91,332 | $720 | $1,200 | $1,819,569 | $26,415 | $204,423 |
| Default Annual Private Station/EVSE O&M Costs ($/yr) | $5,937 | $5,937 | $0 | $0 | $110,994 | $1,717 | $13,287 |
| Annual Private Fueling Labor & Misc. Costs ($/yr) | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| **Public Out of Route Mileage, Labor & Misc. Costs** | | | | | | | |
| LD Annual Out of Route Mileage To Public Station | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LD Out of Route Vehicle Speed (miles/hr) | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| LD Labor Rate ($/hr) | $25 | $25 | $25 | $25 | $25 | $25 | $25 |
| LD Annual Out of Route Labor Costs ($/yr) | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| LD Public Fueling Labor & Misc. Costs ($/yr) | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| **Private Out of Route Mileage, Labor & Misc. Costs** | | | | | | | |
| HD Annual Out of Route Mileage To Public Station | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| HD Out of Route Vehicle Speed (miles/hr) | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| HD Labor Rate ($/hr) | $25 | $25 | $25 | $25 | $25 | $25 | $25 |
| HD Annual Out of Route Labor Costs ($/yr) | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| HD Public Fueling Labor & Misc. Costs ($/yr) | $0 | $0 | $0 | $0 | $0 | $0 | $0 |

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

# AFLEET Tutorial - Simple Payback and TCO Calculators

- **View results on "Payback Outputs" sheet**

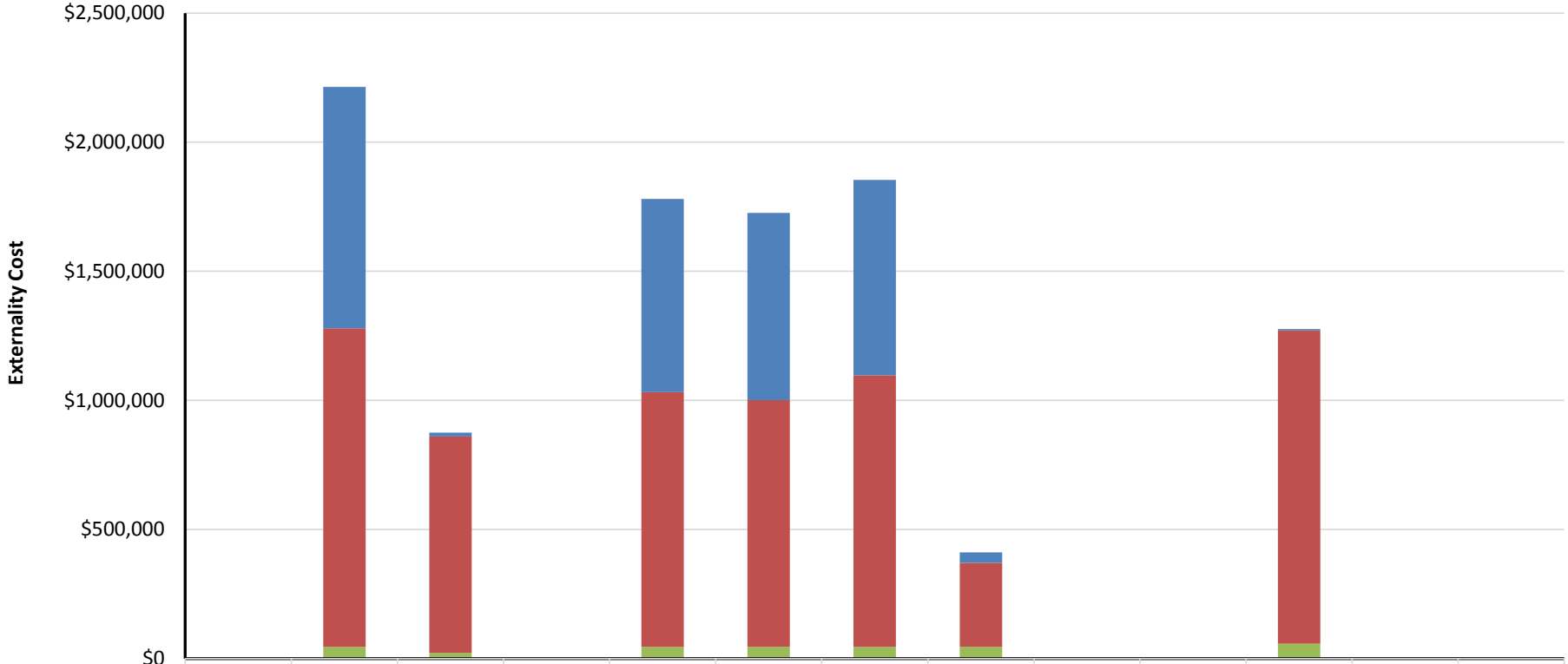



| | Gasoline | Diesel | Gasoline HEV | Gasoline PHEV | Gasoline EREV | EV | G.H2 FCV | B20 | B100 | E85 | LPG | CNG |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Petroleum Use | $35,441 | $30,704 | | $19,844 | $14,508 | $484 | $229 | | | | $11,871 | $190 |
| GHGs | $48,061 | $40,486 | | $31,247 | $29,947 | $27,502 | $32,280 | | | | $42,283 | $42,765 |
| CO | $0 | $0 | | $0 | $0 | $0 | $0 | | | | $0 | $0 |
| NOx | $34 | $67 | | $18 | $13 | $0 | $0 | | | | $35 | $28 |
| PM10 | $659 | $594 | | $649 | $634 | $601 | $601 | | | | $659 | $659 |
| PM2.5 | $3,379 | $3,166 | | $3,133 | $2,765 | $1,923 | $1,923 | | | | $3,379 | $3,379 |
| VOC | $3,677 | $1,765 | | $2,339 | $1,627 | $0 | $0 | | | | $4,107 | $2,069 |
| GHG Emissions | 1,287 | 1,084 | | 837 | 802 | 737 | 864 | | | | 1,132 | 1,145 |

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

# AFLEET Tutorial - Simple Payback and TCO Calculators

- **View results on "TCO Outputs" sheet**




| | Gasoline | Diesel | EV | G.H2 FCV | Diesel HEV | Diesel HHV | B20 | B100 | E85 | LPG | CNG | LNG | LNG / Diesel Pilot Ignition |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Petroleum Use | | $935,502 | $14,741 | | $748,401 | $725,014 | $756,604 | $41,011 | | | $5,389 | | |
| GHGs | | $1,233,57 | $837,967 | | $986,856 | $956,017 | $1,051,78 | $324,649 | | | $1,213,59 | | |
| Air Pollutants | | $45,334 | $22,404 | | $45,334 | $45,334 | $45,334 | $45,334 | | | $57,623 | | |

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

# 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
  - Fuel price sensitivity
  - Infrastructure costs
  - Latest vehicle and emission data
  - Externality costs

# Thank you!!!

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