

Using Argonne's Modeling Software to Estimate Benefits of Alternative Fuel Vehicles

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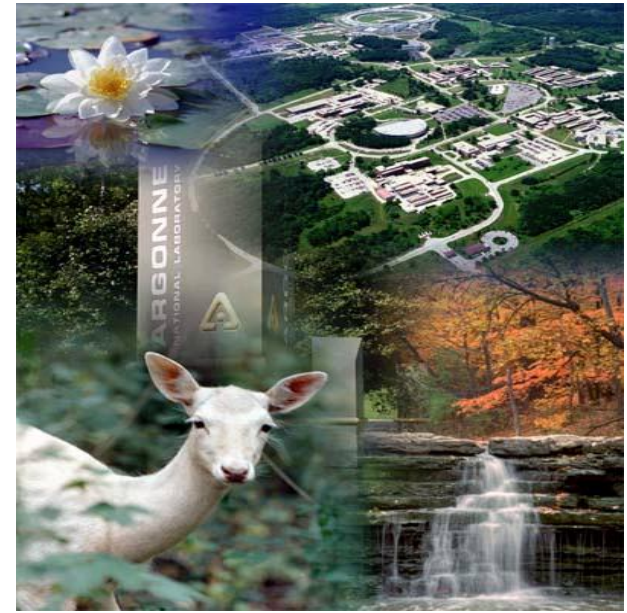
Outline of Presentation

- **Argonne In Brief**
- **Life-Cycle Analysis Introduction and GREET**
- **GREET Fleet Footprint Calculator Introduction**
- **Other Clean Cities Analytical Work**

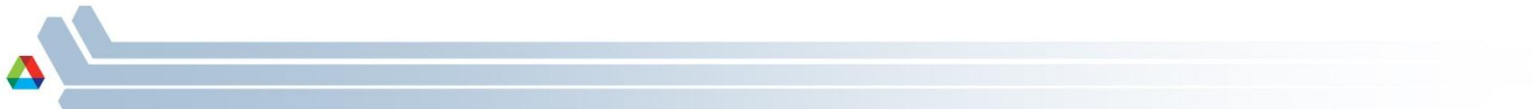


Argonne in Brief

- Founded in 1943, designated a national laboratory in 1946
- Managed by University of Chicago for DOE
 - 3,200 employees and 5,000 facility users
 - Facilities provide tools for basic science and national security research
- Broad-based research and development
 - Center for Transportation Research
 - Advanced Powertrain Research Facility
 - Advanced Battery Development
 - Autonomie Model
 - GREET Model



Life-Cycle Analysis Introduction and GREET

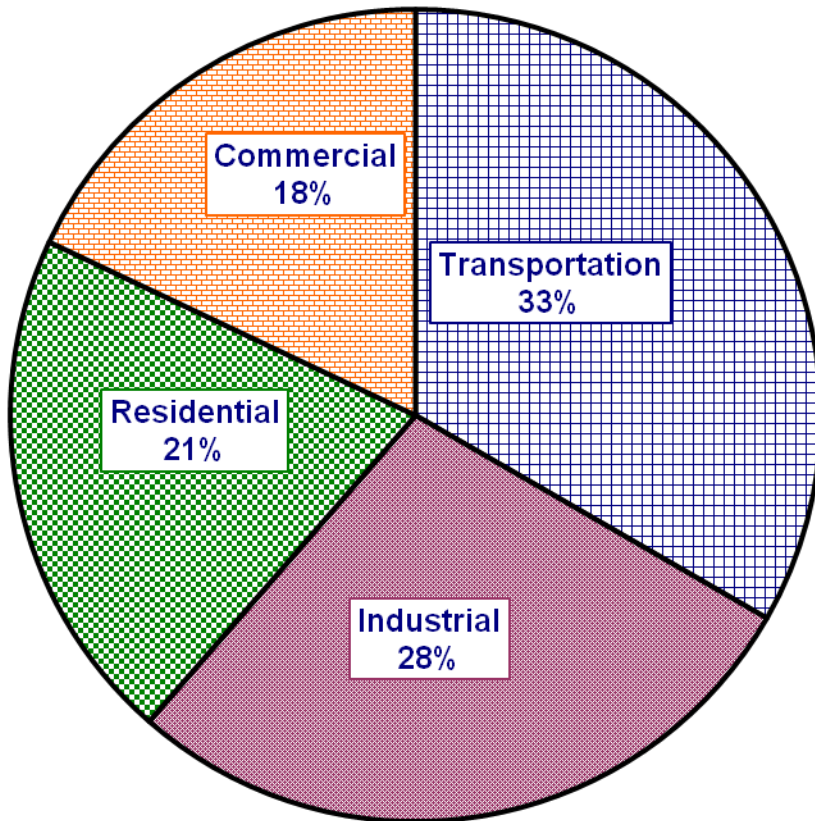


From the Department of Energy's Perspective Transportation Sector: Dual Challenges, Dual Approaches

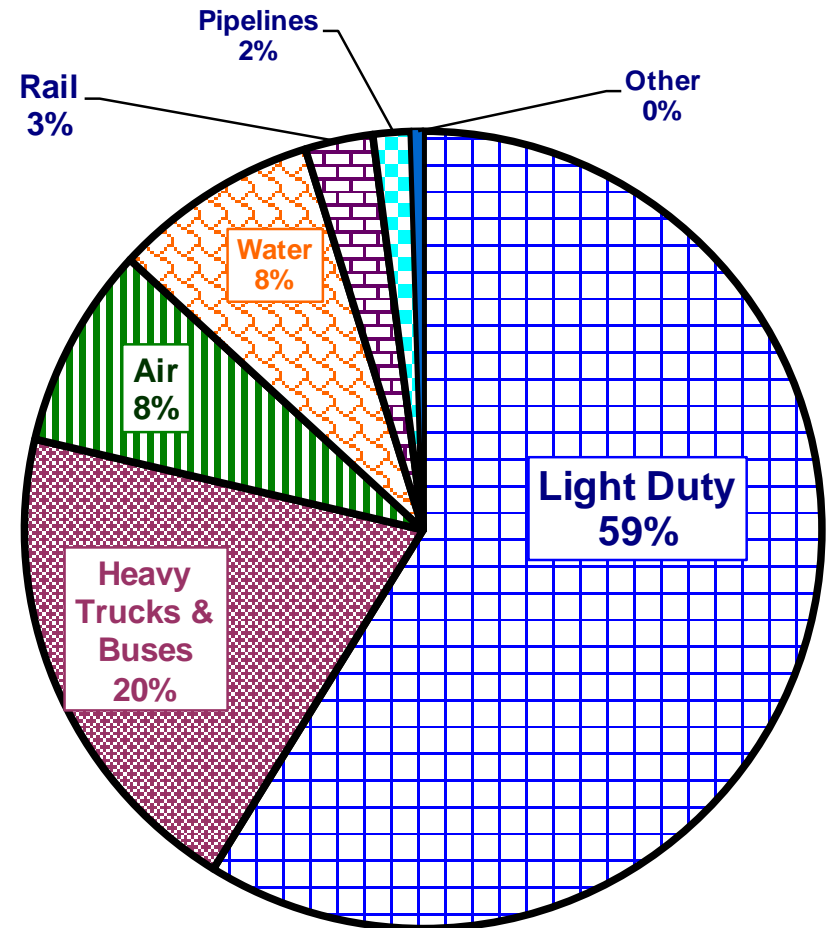
- Challenges
 - Greenhouse gas emissions (climate change)
 - Oil use (energy security)
- Approaches
 - Vehicle efficiency (and transportation system efficiency)
 - New transportation fuels



U.S. Greenhouse Gas Emission Shares by Source



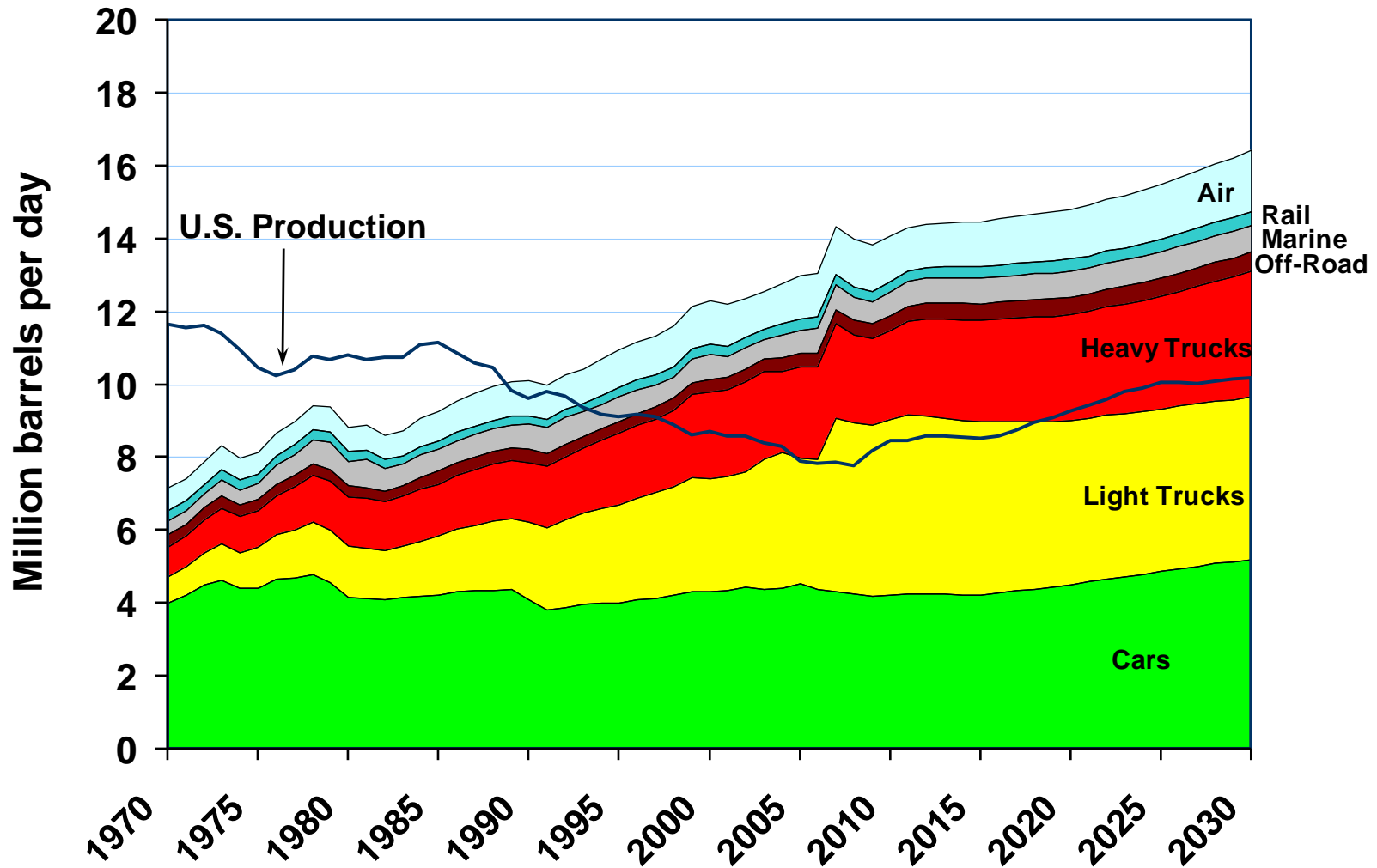
2006 GHG Emissions (CO2 Eqv)



2006 GHG Emissions (CO2 Eqv)

Annual US total GHG emissions are 5.6 GT of CO₂e

U.S. Petroleum Production and Consumption 1970-2030



Sources: *Transportation Energy Data Book: Edition 27* and projections from the *Early Release Annual Energy Outlook 2009*.



Life-Cycle Analysis for Vehicle/Fuel Systems Has Evolved in the Past 25 Years

- Historically, evaluation of vehicle/fuel systems from well-to-wheels (WTW) was called fuel-cycle analysis
- Pioneer transportation 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 hydrogen and biofuels and vehicle technologies such as plug-in hybrids and fuel cells
- Pursuing reductions in transportation GHG emissions demands for intensive and extensive WTW analyses

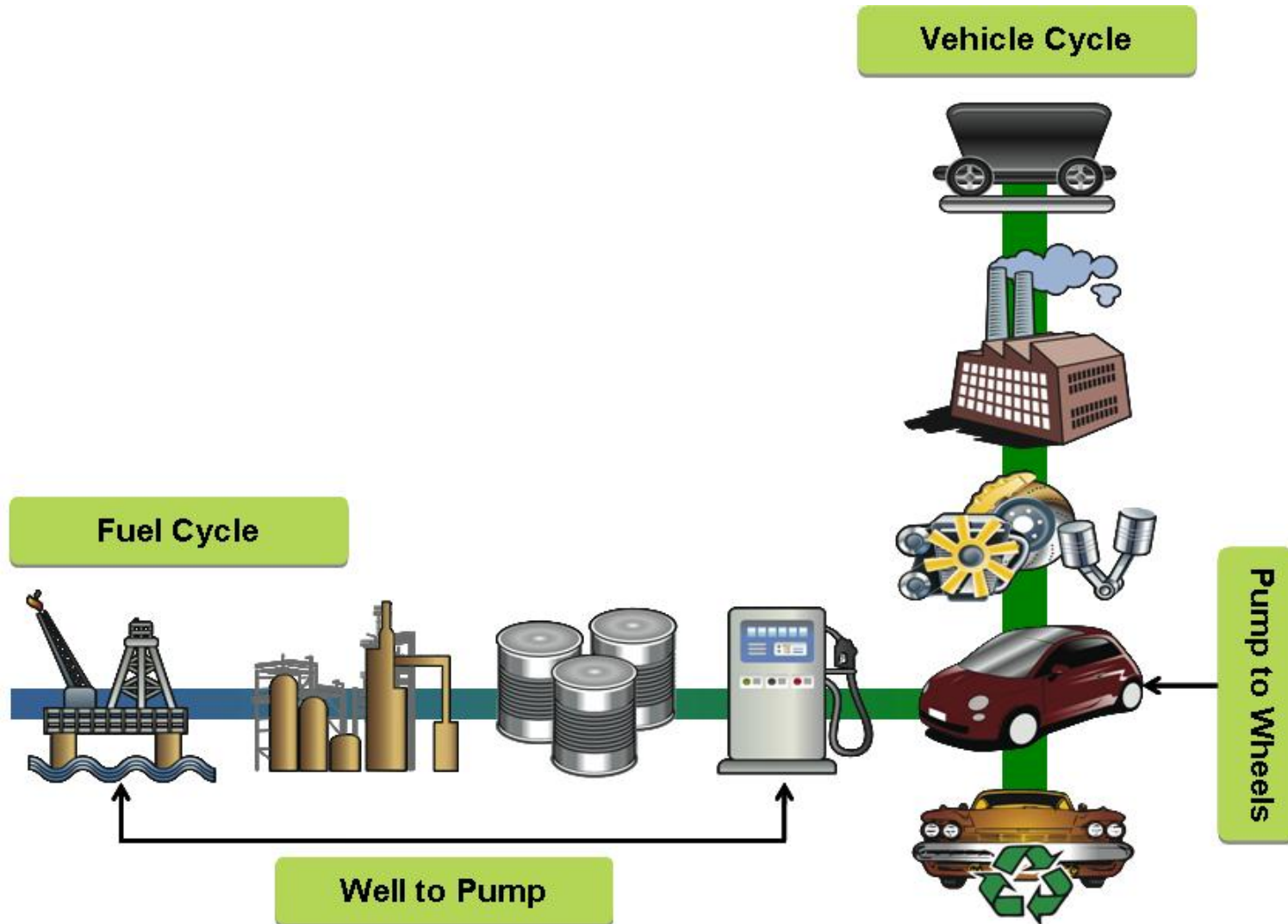


The GREET (Greenhouse gases, Regulated Emissions, and Energy use in Transportation) Model

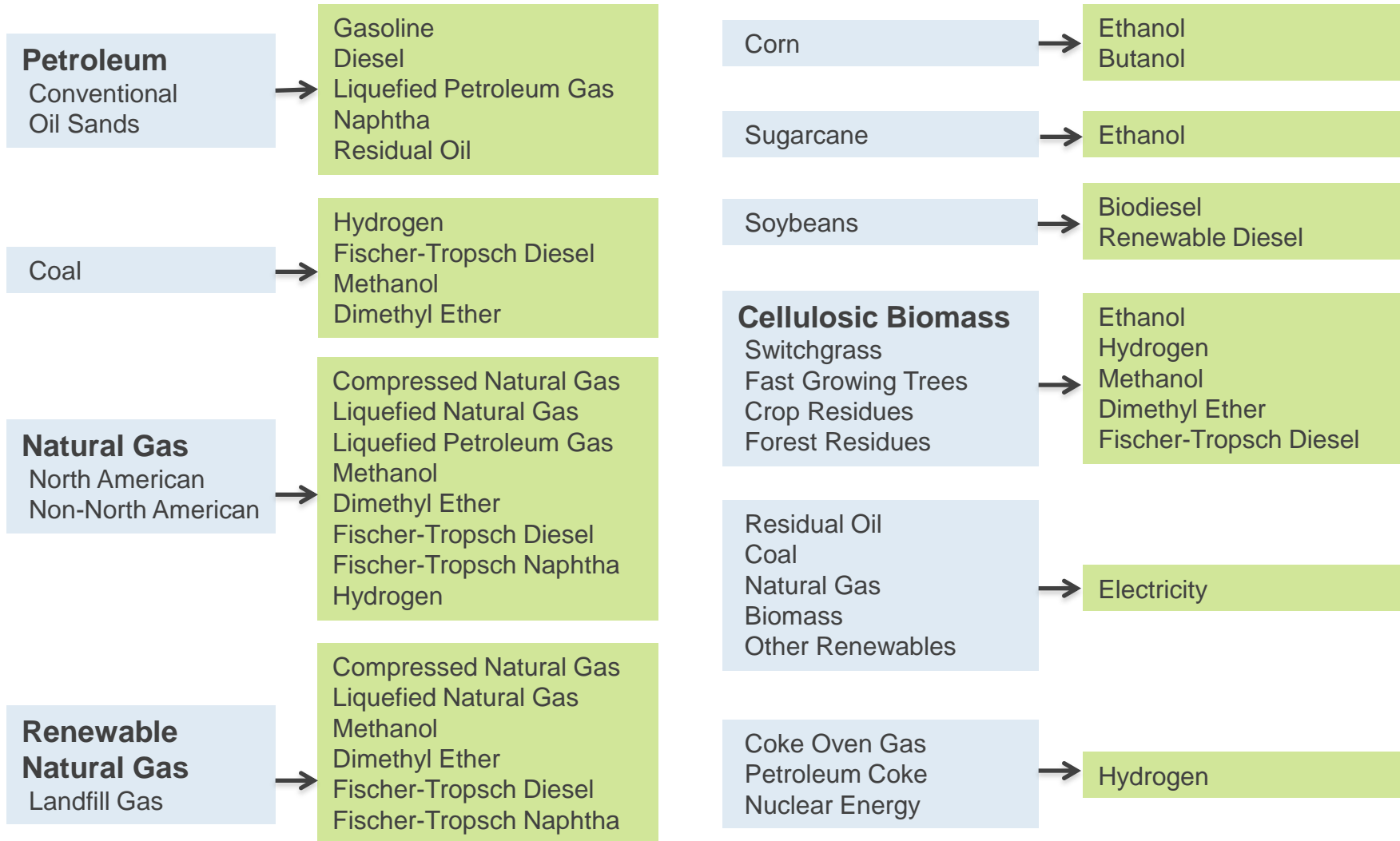
- **Includes emissions of greenhouse gases**
 - CO₂, CH₄, and N₂O
- **Estimates emissions of six criteria pollutants**
 - Total and urban separately
 - VOC, CO, NO_x, SO_x, PM₁₀, and PM_{2.5}
- **Separates energy use into:**
 - All energy sources (fossil and non-fossil)
 - Fossil fuels (petroleum, natural gas, and coal combined)
 - Petroleum
 - Natural gas
 - Coal
- **Model and its documents are available at: <http://greet.es.anl.gov/>**
 - Latest version of the fuel-cycle model (GREET1.8d.1) was released August 2010
 - There are more than 14,000 registered GREET users worldwide



Life-Cycle Analysis of Vehicle/Fuel Systems Includes Both Fuel Cycle and Vehicle Cycle



REET 1.8d Includes More Than 100 Fuel Production Pathways



REET1.8d Examines More Than 82 Vehicle/Fuel Systems

Conventional Spark-Ignition Engine Vehicles

- ▶ Gasoline
- ▶ Compressed natural gas, liquefied natural gas, and liquefied petroleum gas
- ▶ Gaseous and liquid hydrogen
- ▶ Methanol and ethanol

Spark-Ignition, Direct-Injection Engine Vehicles

- ▶ Gasoline
- ▶ Methanol and ethanol

Compression-Ignition, Direct-Injection Engine Vehicles

- ▶ Diesel
- ▶ Fischer-Tropsch diesel
- ▶ Dimethyl ether
- ▶ Biodiesel

Fuel Cell Vehicles

- ▶ On-board hydrogen storage
 - Gaseous and liquid hydrogen from various sources
- ▶ On-board hydrocarbon reforming to hydrogen
 - Methanol
 - Ethanol
 - Gasoline
 - Naphtha
 - Compressed natural gas, liquefied natural gas, and liquefied petroleum gas
 - Diesel

Battery-Powered Electric Vehicles

- ▶ Various electricity generation sources

Hybrid Electric Vehicles (HEVs)

- ▶ Spark-ignition engines:
 - Gasoline
 - Compressed natural gas, liquefied natural gas, and liquefied petroleum gas
 - Gaseous and liquid hydrogen
 - Methanol and ethanol
- ▶ Compression-ignition engines
 - Diesel
 - Fischer-Tropsch diesel
 - Dimethyl ether
 - Biodiesel

Plug-in Hybrid Electric Vehicles (PHEVs)

- ▶ Spark-ignition engines:
 - Gasoline
 - Compressed natural gas, liquefied natural gas, and liquefied petroleum gas
 - Gaseous and liquid hydrogen
 - Methanol and ethanol
- ▶ Compression-ignition engines
 - Diesel
 - Fischer-Tropsch diesel
 - Dimethyl ether
 - Biodiesel



GREET 2.7 Simulates Vehicle-Cycle Energy Use and Emissions for Conventional and Advanced Vehicles



- Raw material recovery
- Material processing and fabrication
- Vehicle component production
- Vehicle assembly
- Vehicle disposal and recycling

GREET Fleet Footprint Calculator Introduction



GREET Fleet Allows Users to Estimate Petroleum and Carbon Footprints

- Starting in 1998, US DOE and EPA co-sponsored Argonne to develop a tool, AirCRED, to assist Clean Cities coalitions to estimate ozone precursor and carbon monoxide emission credits from AFVs
 - For use in State Implementation Plans (SIPs)
- Now with the interest in measuring petroleum use and carbon/greenhouse gas emissions, Clean Cities sponsored Argonne to develop the GREET Fleet Footprint Calculator
 - Developed in Microsoft Excel and uses simple spreadsheet inputs
 - Results are on WTW basis
- This tool was designed for:
 - On-road-medium and heavy-duty vehicles
 - Off-road equipment

REET Fleet is Available for Download

- **Contains 12 fuel/vehicle types**
 - Conventional: gasoline and diesel
 - Hybrid: diesel HEV
 - Alt. fuel: biodiesel (B20 and B100), ethanol (E85), CNG, LNG, LPG, electricity, gaseous and liquid hydrogen
 - Additional simulation options include:
 - Corn vs. cellulosic ethanol
 - North American NG vs. Non North American NG vs. Landfill Gas
 - Electricity mix (% coming from coal, natural gas, nuclear, etc.)
 - Several hydrogen production pathways
- **REET Fleet is based off the current public version of REET (1.8d.1)**
 - Calculations in REET Fleet will be updated as they change in the REET model
 - Our grand plan is to develop include heavy-duty vehicles in the REET model
- **You can find REET Fleet and its user manual at:**
[http://greet.es.anl.gov/fleet footprint calculator](http://greet.es.anl.gov/fleet_footprint_calculator)



REET Fleet Can Compare Footprints for Potential AFV Acquisitions

- All you need to enter is:
 - Number of vehicles to be purchased
 - Estimated annual mileage for these vehicles (we have placeholder info)
 - Fuel economy (we have placeholder info)

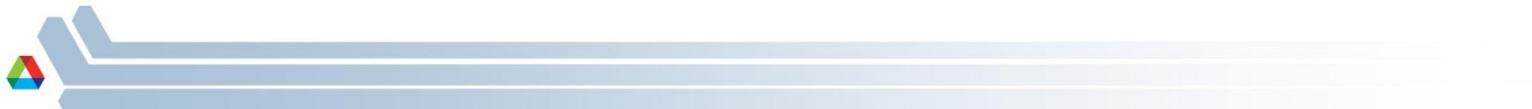


Calculating Your Existing Fleet's Footprint Can Be Done Simply Using GREET Fleet

- All you need to enter is:
 - Amount of fuel used (in gallons, cubic feet, kWh, etc.)



Other Clean Cities Analytical Work



ARRA Data Collection

- What do we need to accomplish with the required ARRA data collection?
 - Document the benefits of these projects
 - How much petroleum is displaced and emissions are reduced?

- What lessons can we learn we address with a deeper dive into the ARRA projects?
 - Need a greater understanding of fleet operations
 - There is a lack of publically available information on specific vocations
 - What is the fuel consumption, refueling patterns, driving range requirements, etc. for a specific vocation (e.g. a taxi fleet)
 - This information can help with market analysis and allow stakeholders to better target the “right” fleets
 - Positive and negative experiences in adopting an alternative fuel vehicle
 - How can the experience be improved?



Thank you!!!

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