

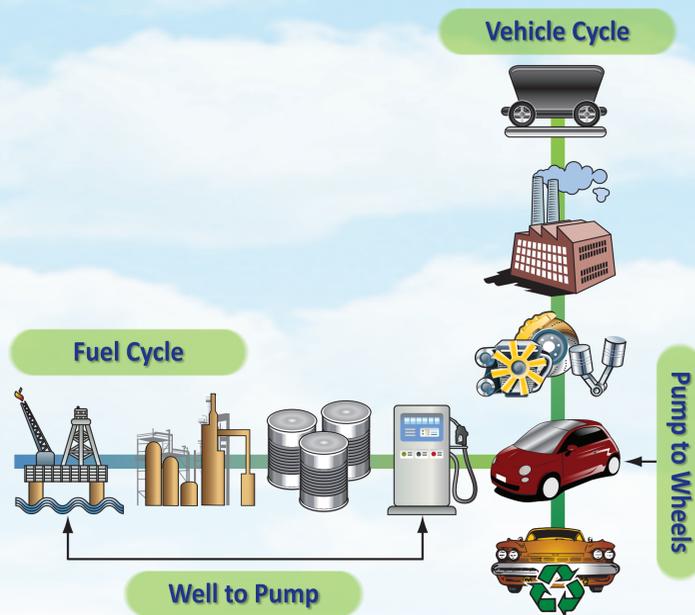
Argonne's GREET Model Examines Fuel Cycle Energy and Emissions

GREET = Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation

Sponsored by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy, Argonne developed a full life-cycle model called GREET. GREET is a widely used tool that allows researchers to evaluate various vehicle and fuel combinations on a consistent full life-cycle basis.

The current version of the GREET model, updated in 2009, compares the life-cycle energy and emissions of more than 82 vehicle/fuel combinations. GREET can tell you how much energy goes into a full range of vehicles from sports utility vehicles to hybrid vehicles.

Life Cycles for Vehicle/Fuel Systems



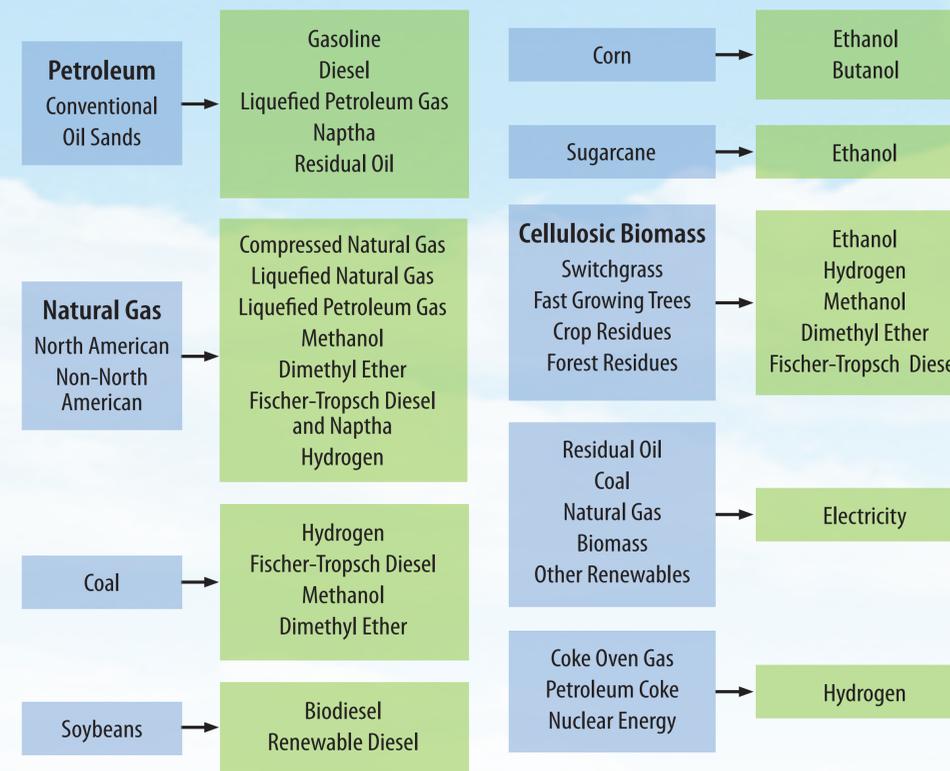
How GREET Works

For any given vehicle technology and fuel type, GREET separately calculates the energy consumption by energy type such as oil, natural gas, or coal.

For a given vehicle and fuel system, GREET calculations:

- ▶ **Include emissions of greenhouse gases**
 - carbon dioxide (CO₂)
 - methane (CH₄)
 - nitrous oxide (N₂O)
- ▶ **Estimate emissions of six criteria pollutants**
 - total and urban separately
 - volatile organic compounds (VOCs)
 - carbon monoxide (CO)
 - nitrogen oxides (NO_x)
 - sulfur oxides (SO_x)
 - particulate matter
 - size smaller than 10 microns (PM₁₀) but larger than 2.5 microns
 - size smaller than 2.5 microns (PM_{2.5})
- ▶ **Separate energy use into**
 - all energy sources (fossil and non-fossil)
 - fossil fuels (petroleum, natural gas, and coal combined)
 - petroleum
 - natural gas
 - coal

GREET Includes More Than 100 Fuel Production Pathways from Various Energy Feedstocks



The blue boxes contain the names of the feedstocks and the green boxes contain the names of the fuels that can be produced from each of those feedstocks.

GREET 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

There are more than 10,000 users of GREET worldwide, including government agencies, the auto and energy industries, research institutions, universities, and public interest groups. Argonne uses GREET to evaluate various vehicle and fuel systems for the DOE and other government agencies.

The first version of GREET was released in 1996. Developed as a multidimensional spreadsheet model in Microsoft® Excel, GREET was enhanced with a graphical user interface program. This public domain model is available free of charge.

For more information, visit www.transportation.anl.gov/modeling_simulation/GREET/