

GREET: A Life-Cycle Analysis Model for Alternative Vehicle/Fuel Systems

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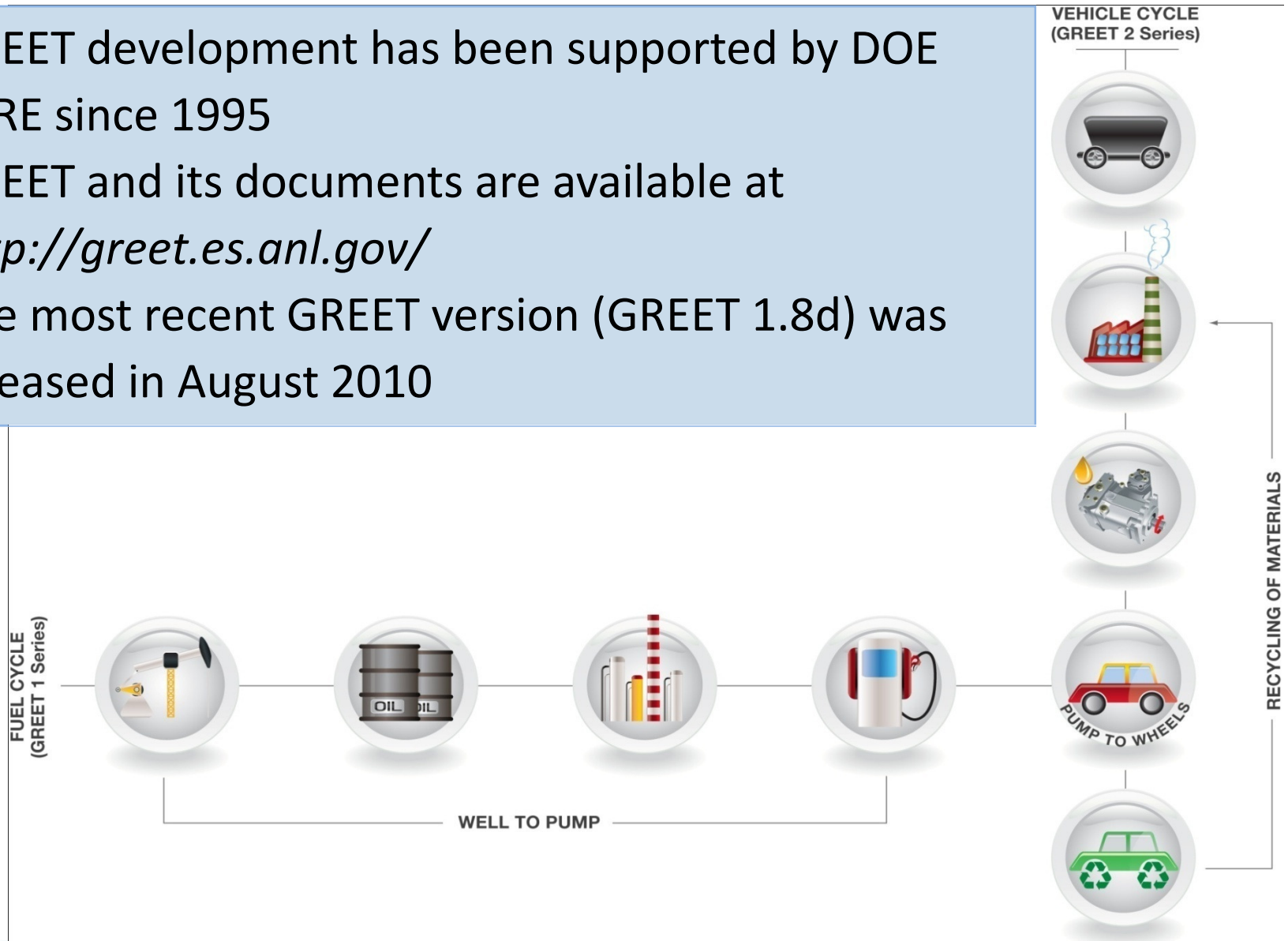
Presentation at Asia Pacific Clean Energy Summit

Honolulu, Hawaii

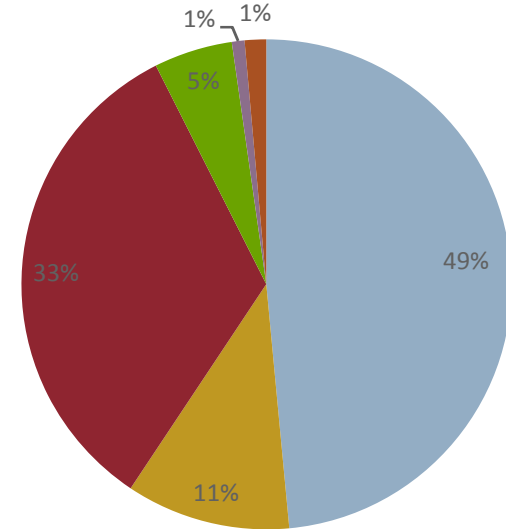
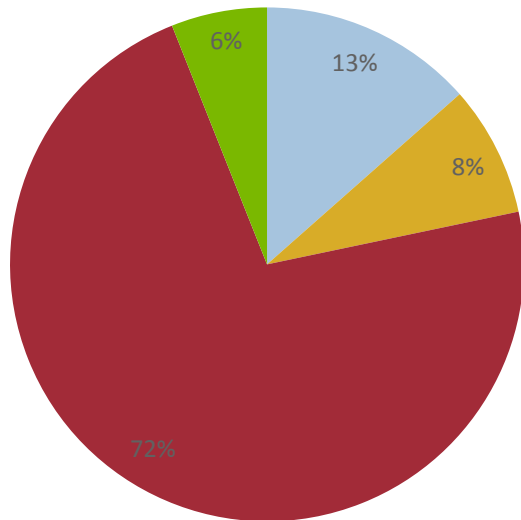
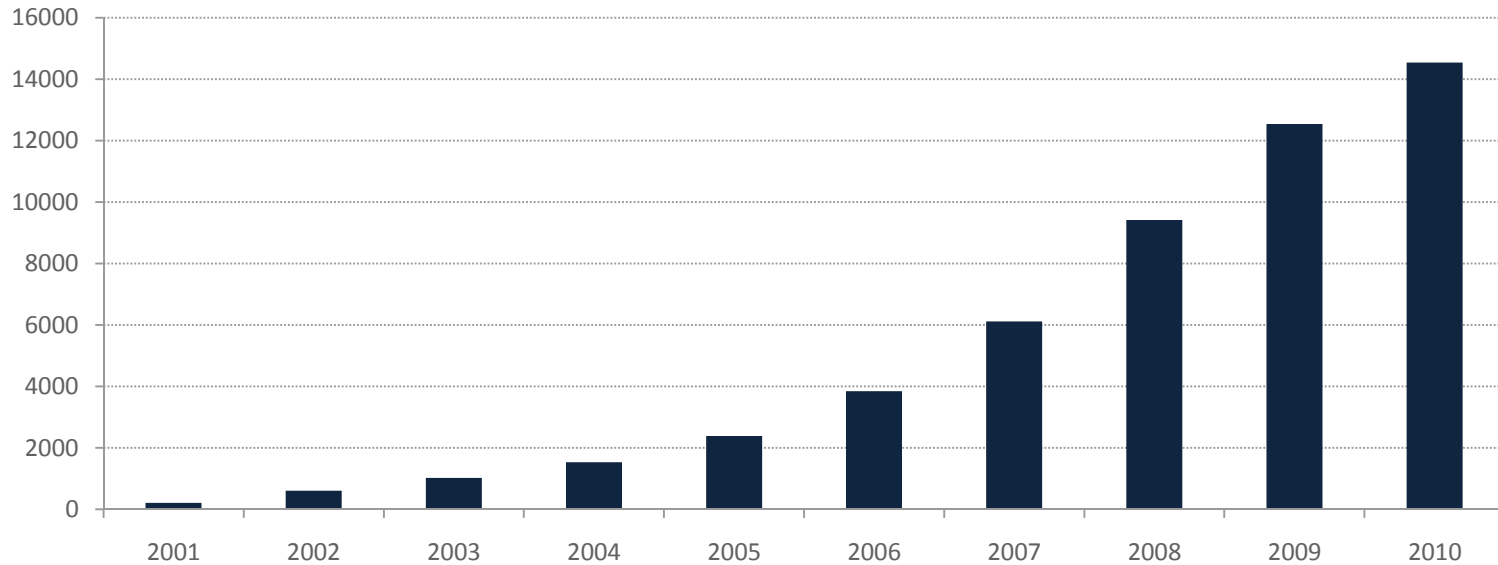
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The GREET (Greenhouse gases, Regulated Emissions, and Energy use in Transportation) Model

- ❑ GREET development has been supported by DOE EERE since 1995
- ❑ GREET and its documents are available at <http://greet.es.anl.gov/>
- ❑ The most recent GREET version (GREET 1.8d) was released in August 2010



There Are More Than 14,000 Registered GREET Users Worldwide

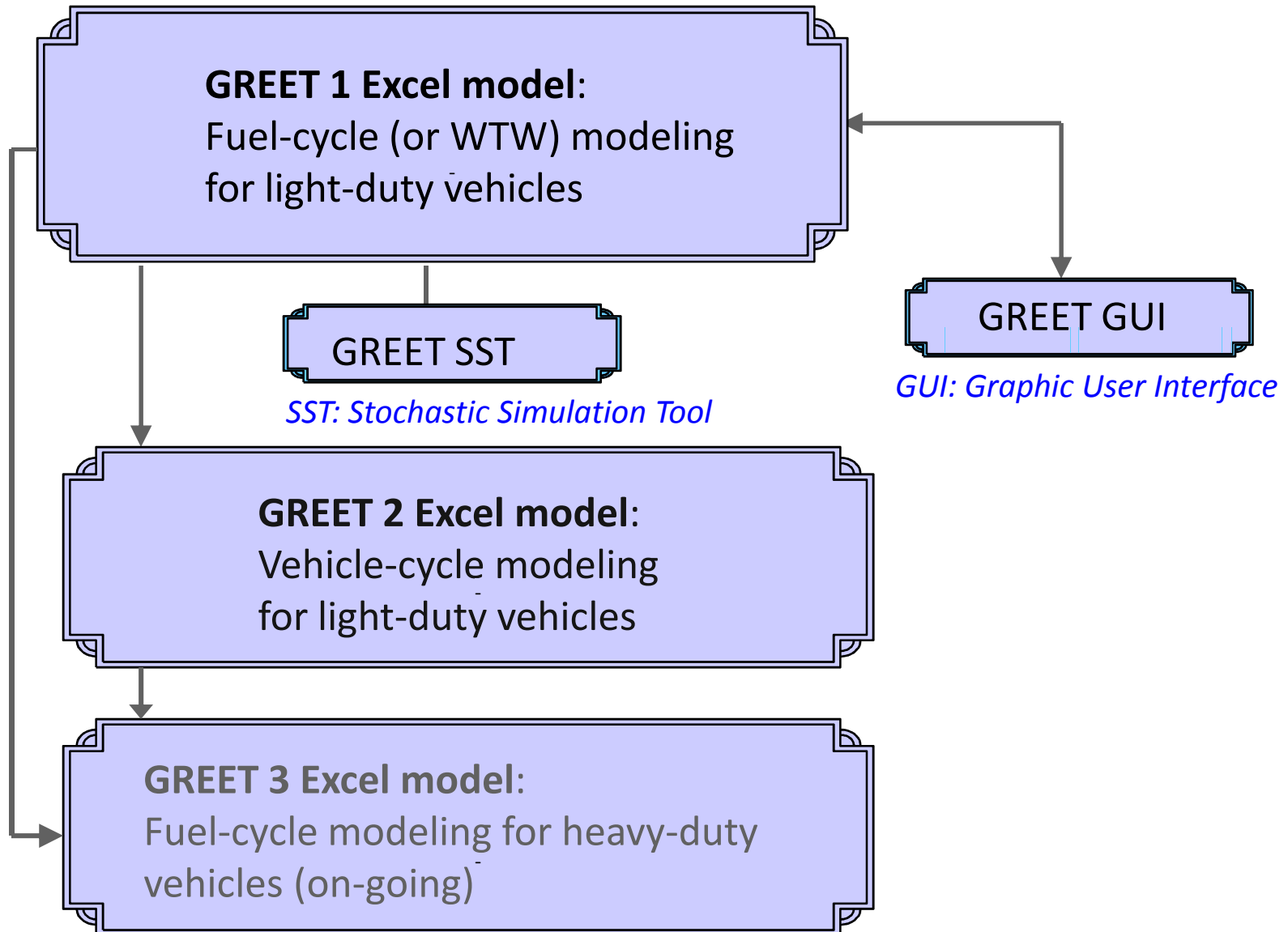


■ Europe
 ■ Asia
 ■ North America
 ■ Others

■ Academia/education
 ■ Government agency
 ■ Industry
■ Private consulting
 ■ Non-profit organization
 ■ Research institution



The Suite of GREET Models



GREET Covers Emissions and Energy Use

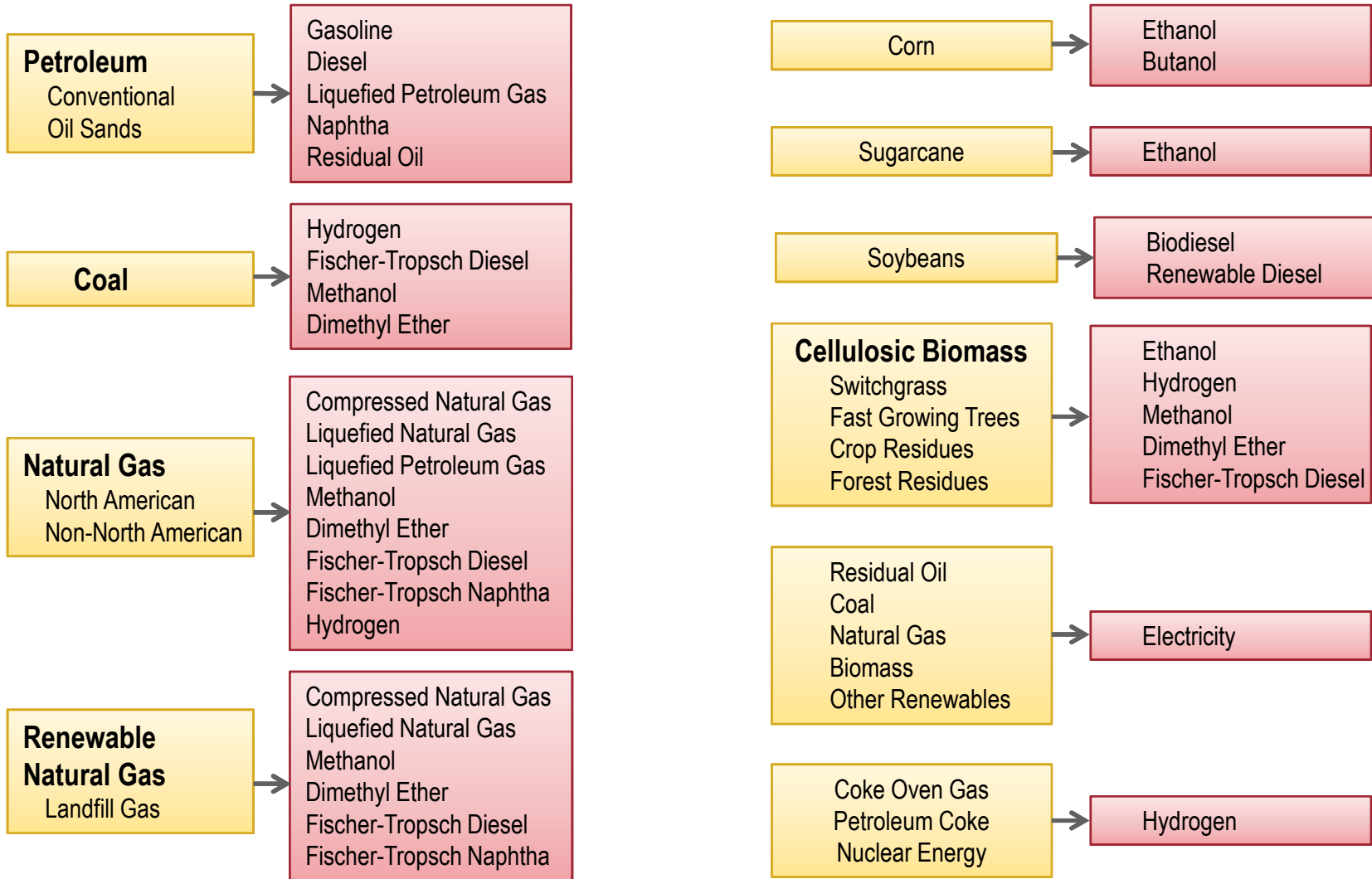
- GREET includes emissions of greenhouse gases (GHGs)
 - CO₂, CH₄, and N₂O
 - VOC, CO, and NO_x as optional GHGs

- GREET estimate emissions of six criteria pollutants (total and urban separately)
 - VOC, CO, NO_x, PM₁₀, PM_{2.5}, and SO_x

- GREET separates energy use into
 - All energy sources
 - Fossil fuels
 - Petroleum
 - Natural Gas
 - Coal



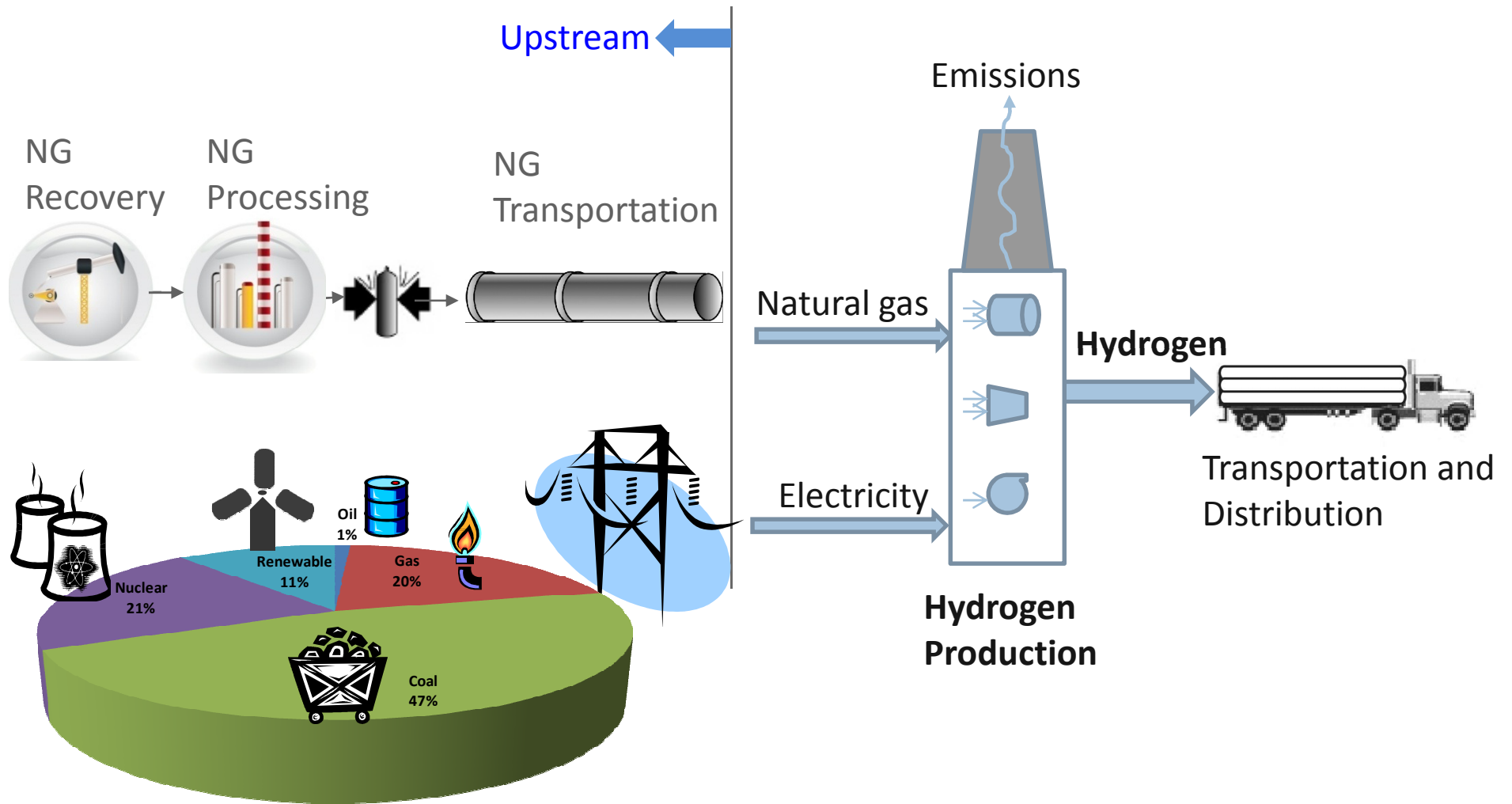
REET Includes More Than 100 Fuel Production Pathways from Various Energy Feedstock Sources



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



Example of Fuel Production (WTP) Pathway in GREET



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

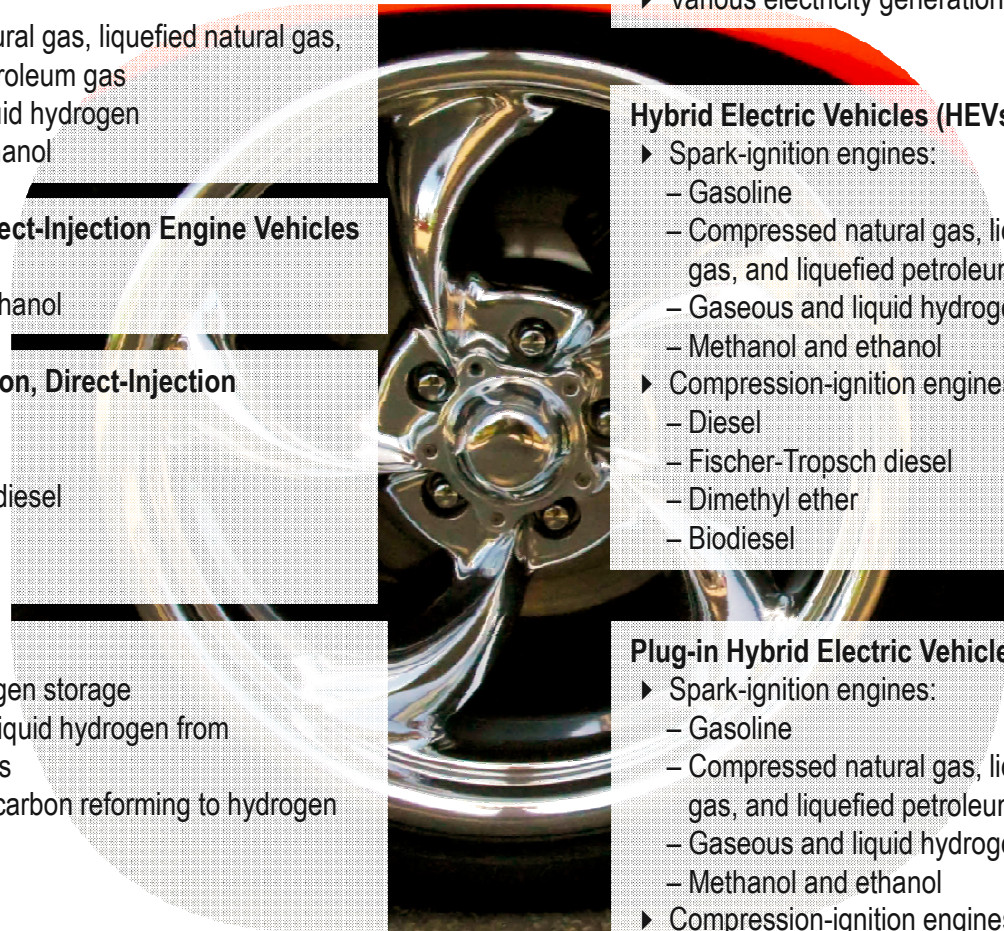
- ▶ Various electricity generation sources

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



WTW Results Are Determined by These Key Factors

□ Well-To-Pump (WTP) Activities

- Energy efficiencies of fuel production activities
- GHG emissions of fuel production activities
- Criteria air pollutant emissions
 - ✓ Stationary combustion processes
 - ✓ Non-combustion processes
 - ✓ Electric power plants

□ Vehicle Operation (PTW)

- Fuel economy of vehicle technologies
- Tailpipe emissions



Data Collection is Critical for Credible LCAs: Argonne's Approach for GREET Development and Applications

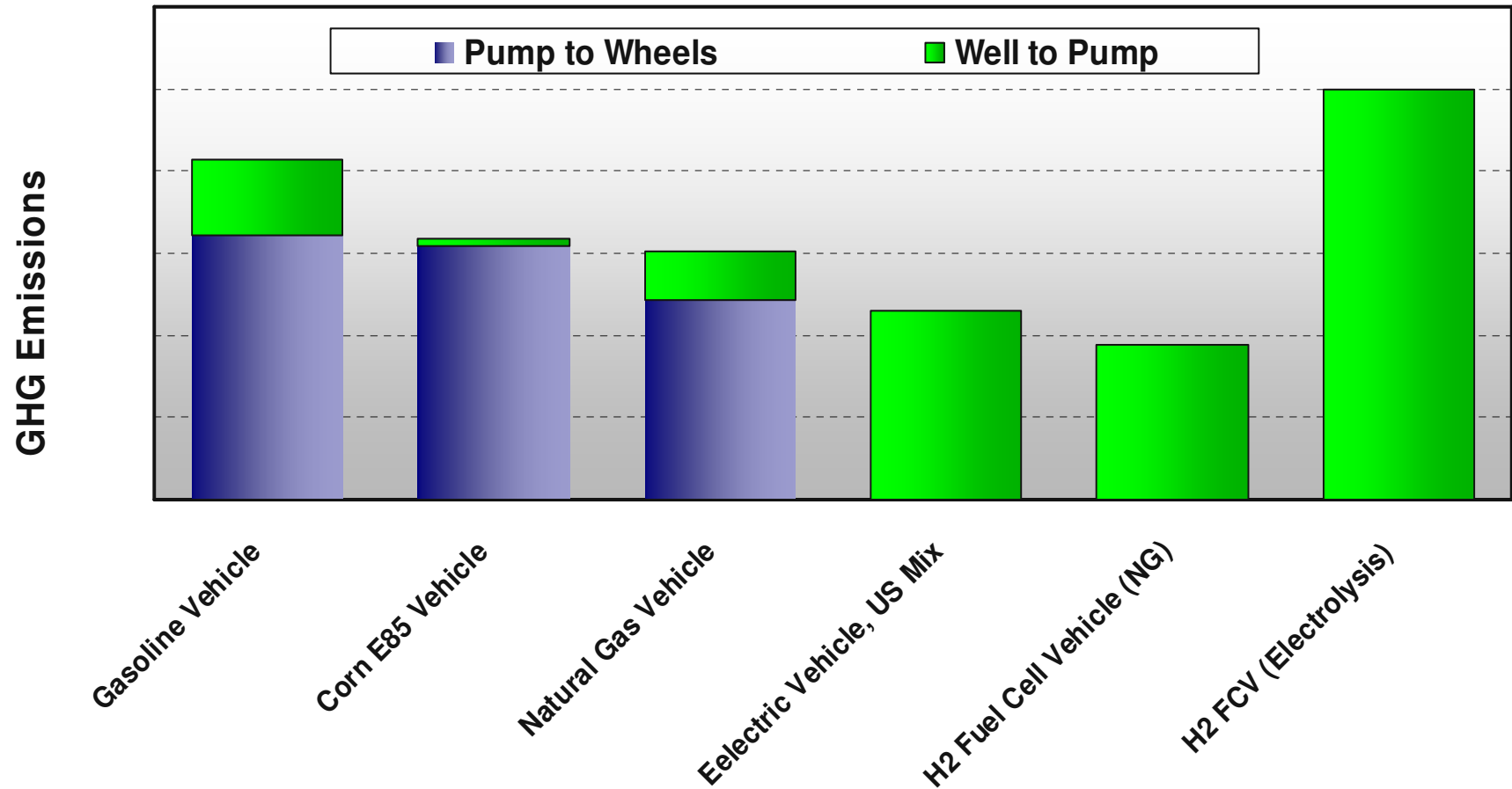
- ❑ Fuel production and stationary activities (WTP)
 - Pursue available data from government agencies and other sources
 - Engage stakeholders (e.g., the energy industry and the biofuel industry) in data collection and verification
 - Conduct our own process engineering modeling

- ❑ Vehicle operations (PTW)
 - Fully engage with our vehicle testing group
 - Examine consistency among different testing efforts and among different databases



WTW Analysis is a Complete Energy/Emissions Comparison

As an example, greenhouse gases emissions are illustrated here





Major Updates in New GREET Release (Expected this month)

- Algae to liquid fuels
- Fast pyrolysis of biomass to liquid fuels
- Aviation (Jet) fuels
- Shale gas
- Renewable natural gas



Development of GREET New Platform (.net)

- ❑ User-friendly → Visualization
- ❑ LCI structured database
- ❑ Data comparison and display
 - ✓ Intermediate outputs, tables, graphs
- ❑ Interaction and data exchange
- ❑ Expandability → Modularization
- ❑ Online wiki help and documentation
- ❑ Beta version for testing by selected users expected next month





Questions/Comments?

