Emissions Modeling: GREET Life Cycle Analysis

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Project ID: van002

Project Overview

Timeline

- Start: Oct. 1993
- End: not applicable (ongoing annual allocation
- % complete: 70% (for FY14)

Budget (all from DOE)

- Total funding since the beginning: $6.0 M
- Funding for FY13: $400K
- Funding for FY14: $400K

Barriers to Address

- Indicators and methodology for evaluating environmental sustainability
- Evaluate energy and emission benefits of vehicle/fuel systems
- Overcome inconsistent data, assumptions, and guidelines
- Develop models and tools
- Conduct unplanned studies and analyses

Partners/Collaborators

- Other research teams funded by VTP
- Other federal/state agencies
- Industry stakeholders

Relevance

- **Provide a consistent platform for comparing energy use and emissions of vehicle/fuel systems:**
  - ✓ Include fuel cycle (a.k.a well-to-wheels or WTW), and vehicle manufacturing cycle (a.k.a. vehicle cycle) for a complete life-cycle analysis (LCA)
  - ✓ Establish a baseline of life-cycle energy use and emissions for baseline fuels and vehicle technologies
  - ✓ Evaluate energy and emissions of new fuel production pathways and advanced vehicle technologies
  - ✓ Identify major contributors to LCA energy use and emission results
- **Assist VTP:**
  - ✓ Evaluate the energy and emission impacts of deploying new fuels and advanced vehicle technologies
  - ✓ Identify R&D priorities to reduce energy and emission footprints of vehicle/fuel systems
- **Support existing DOE-sponsored tools:**
  - ✓ Collaborate with other model developers and lab partners
  - ✓ Collaborate with industry for input and review
- **Assist fuel producers/providers and regulatory agencies to evaluate fuel and vehicle technologies with respect to greenhouse gas (GHG) metrics**

Approach, Data Sources, and General Assumptions

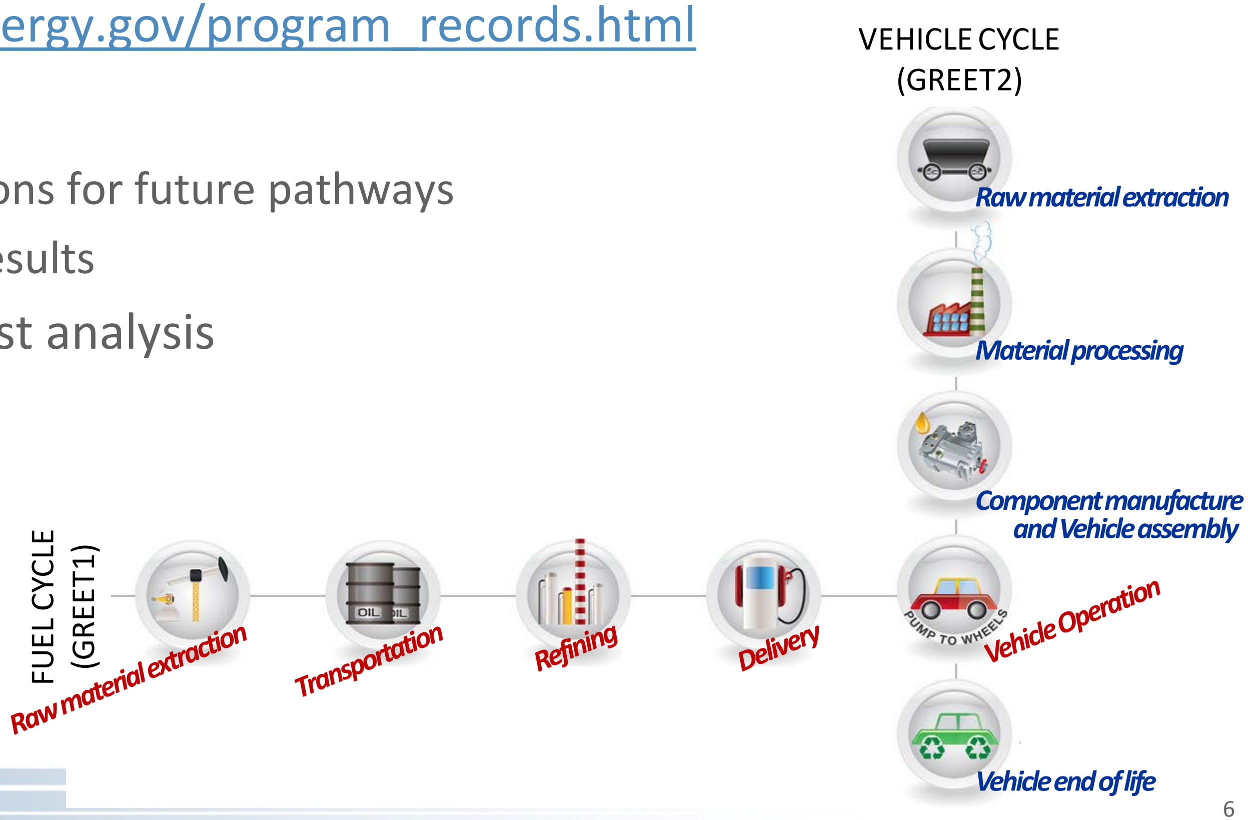
- **Approach: build LCA modeling capacity with the GREET model**
  - Build a consistent LCA platform with reliable, widely accepted methods/protocols
  - Address emerging LCA issues related to vehicle/fuel systems
  - Maintain openness and transparency of LCAs with availability of GREET
- **Data Sources:**
  - Data for fuel production pathways
    - Open literature and results from other researchers
    - Simulation results with models such as ASPEN Plus
    - Fuel producers and technology developers
  - Data for vehicle systems
    - Open literature and results from other researchers
    - Simulation results from models such as Autonomie
    - Auto makers and system components producers
- **General Assumptions:**
  - Baseline technologies and energy systems: EIA AEO projections, EPA eGrid for electric systems, etc.
  - Evolution of both baseline technologies and new technologies over time
  - Consideration of effects of regulations already adopted by agencies

Key Milestones

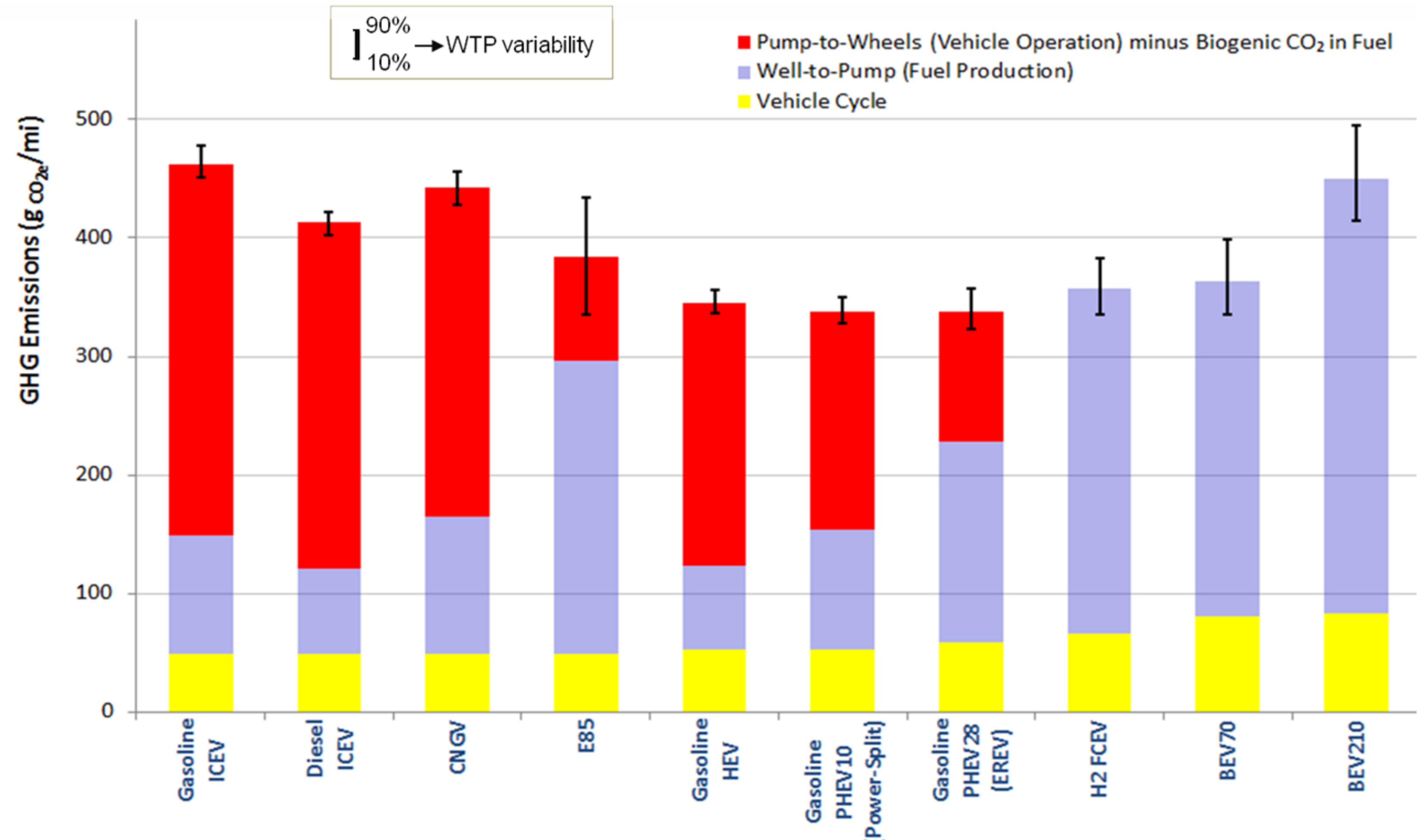
- Evaluate the Cradle-To-Grave energy use and GHG emissions for selected fuel/vehicle combinations as a part of U.S. DRIVE C2G team effort
  - Incorporate the C2G team members feedbacks on fuel productions, and vehicle manufacturing, recycling and operations
  - Evaluate the contribution of vehicle cycles to C2G results and the potential benefits of potential vehicle efficiency gain and low-carbon energy sources.
- Develop GREET in a new platform to improve GREET usability and functionality
- Incorporate water consumption in LCA for primary fuel pathways in GREET
  - Evaluate water consumption for fuel production by water treatment options, process water, cooling water and upstream and indirect water use
- Update fuel-cycle (WTW) simulations of baseline fuels
  - Update methane leakage assumptions for natural gas pathways
  - Update oil sand production and petroleum refining parameters for baseline gasoline and diesel pathways
- Update vehicle-cycle analysis of conventional and advanced vehicle propulsion systems
  - Update battery production and assembly assumptions
  - Update key material production parameters

Cradle-To-Grave Analysis: USDRIVE C2G Team Effort

- Argonne conducted C2G analysis with GREET, with inputs from C2G team members
- System boundary: vehicle manufacturing and recycling phases in addition to fuel production and combustion
- Phase I completed
  - DOE Record is available at:
    http://www.hydrogen.energy.gov/program_records.html
- Phase II:
  - Developed key assumptions for future pathways
  - Generated preliminary results
  - Provide support for cost analysis

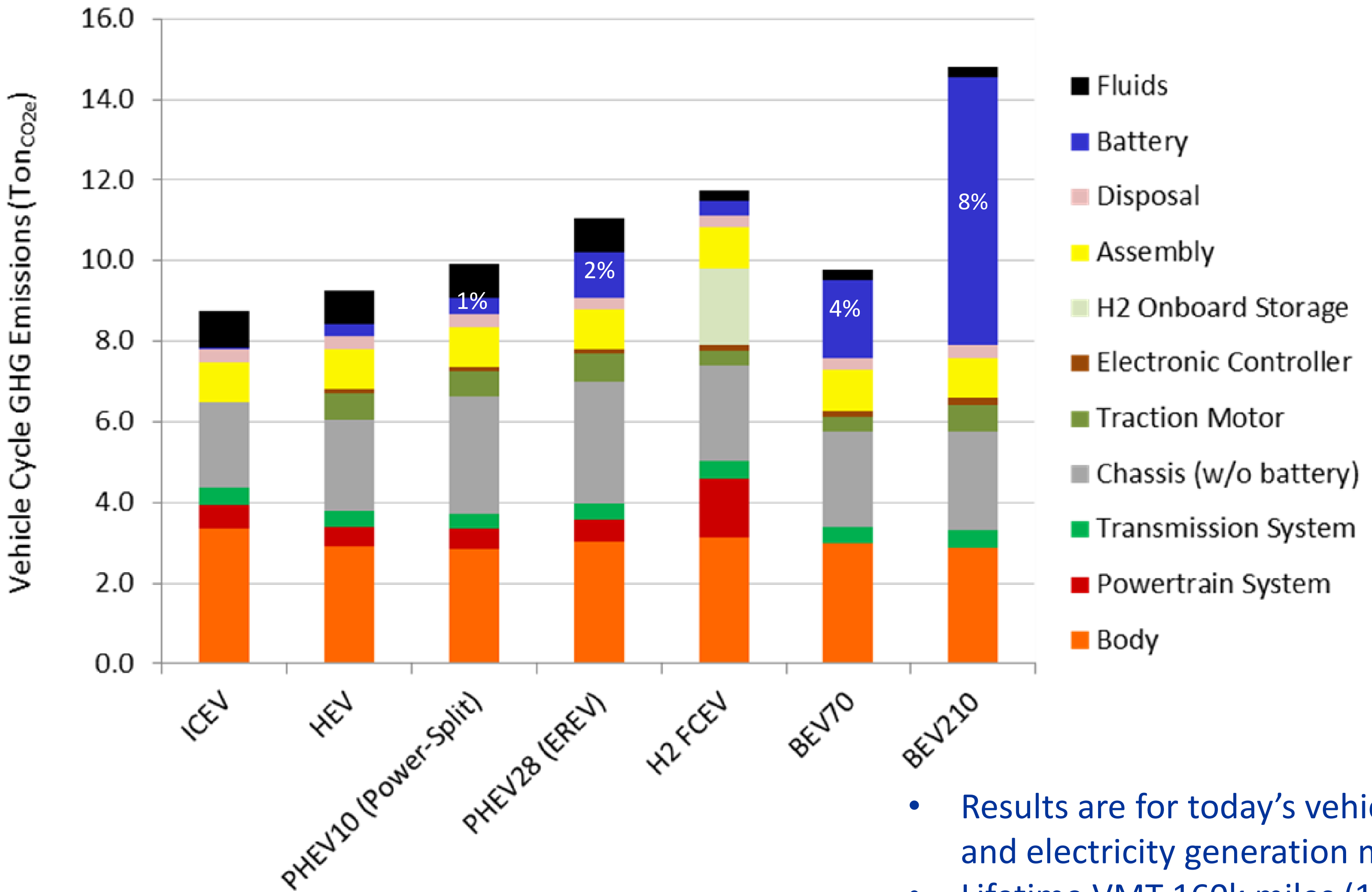


Vehicle manufacturing cycle contributes to 10-22% GHG emissions for today's vehicles



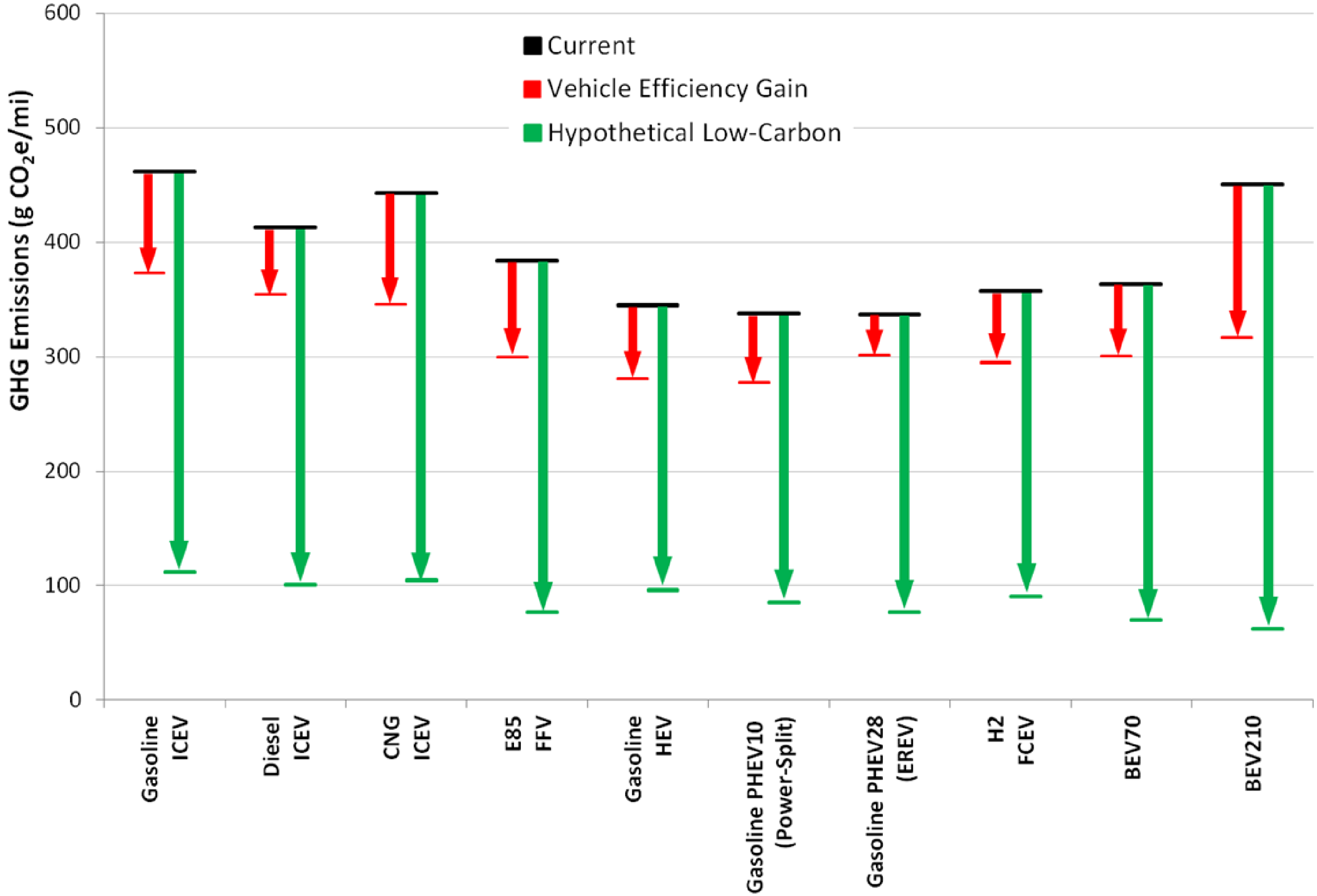
Including parametric variability highlights the variability in GHG burdens of fuel pathways

For today's PEVs, battery manufacturing contributes to 1-8% of C2G GHG emissions



- Results are for today's vehicle technologies and electricity generation mix
- Lifetime VMT 160k miles (110k for BEV70)

“Bookends” of results show that large GHG reductions require both efficiency gains and low-carbon energy sources



GREET.net Development (http://greet.es.anl.gov/greet/)

- 267 fuels, feedstocks, materials, and other resources
- 746 processes
- 483 pathways

A fresh design for GREET life cycle analysis tool

GREET 2013 provides the user with an easy to use and fully graphical toolbox to perform life cycle analysis simulations of alternative transportation fuels and vehicle technologies in a matter of a few clicks. This new tool includes the data of the GREET model, a fast algorithm for processing it and an interactive user interface. The interface allows faster development using graphical representation of each element in the model, and drag & drop editing approach to add and modify data.

DOWNLOAD AND INSTALL NEW GREET PLATFORM

- Explore major features
  Interactive ways to solve LCA studies
- Differences between versions
  Details about what has changed in this new release and changelog
- Documentation
  Available documentation for the software
- API for developers
  Documentation for the GREET API
- Available modules for GREET
  Lists the available modules for GREET
- Contact the GREET team
  Questions regarding the use of the software or assumption in the data
- FAQ
  Frenquently asked questions

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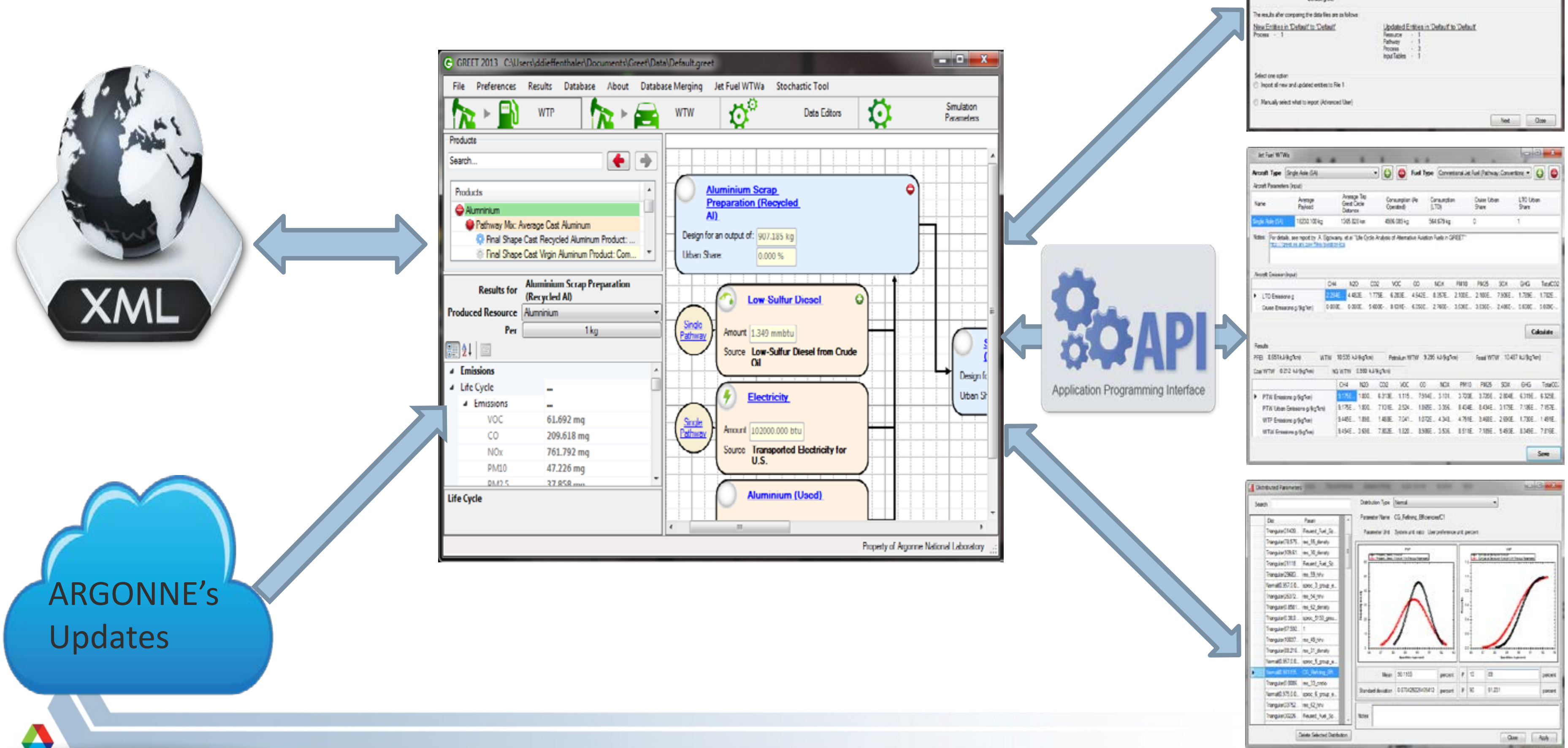
Modular User Interface and Structured Database

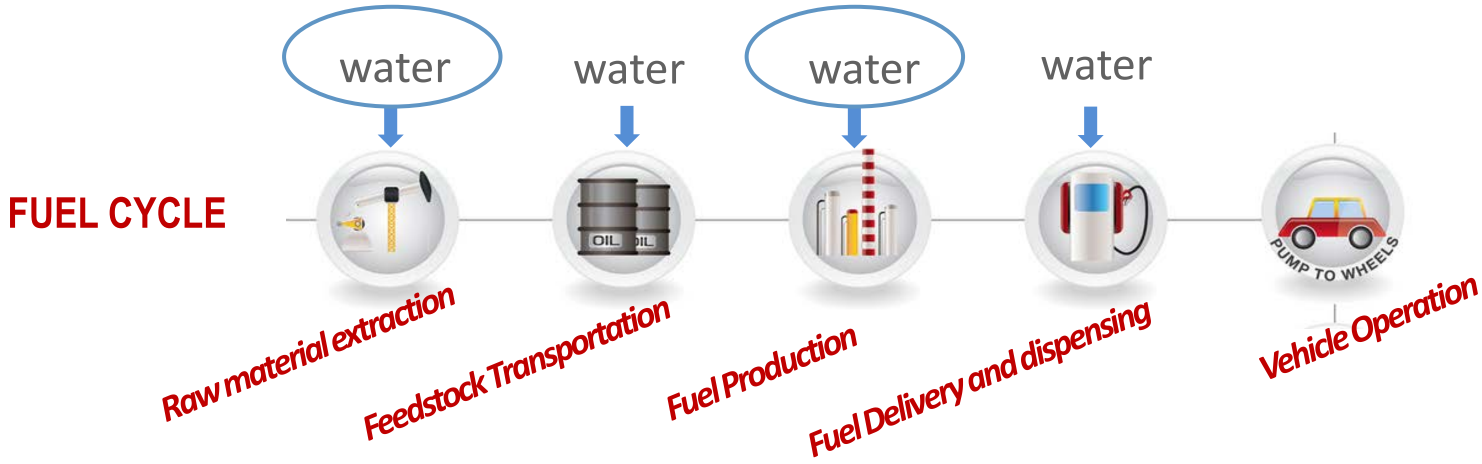
Provides efficient and standardized LCA model and database sharing

Minimizes time to add new data or update from Argonne's data server

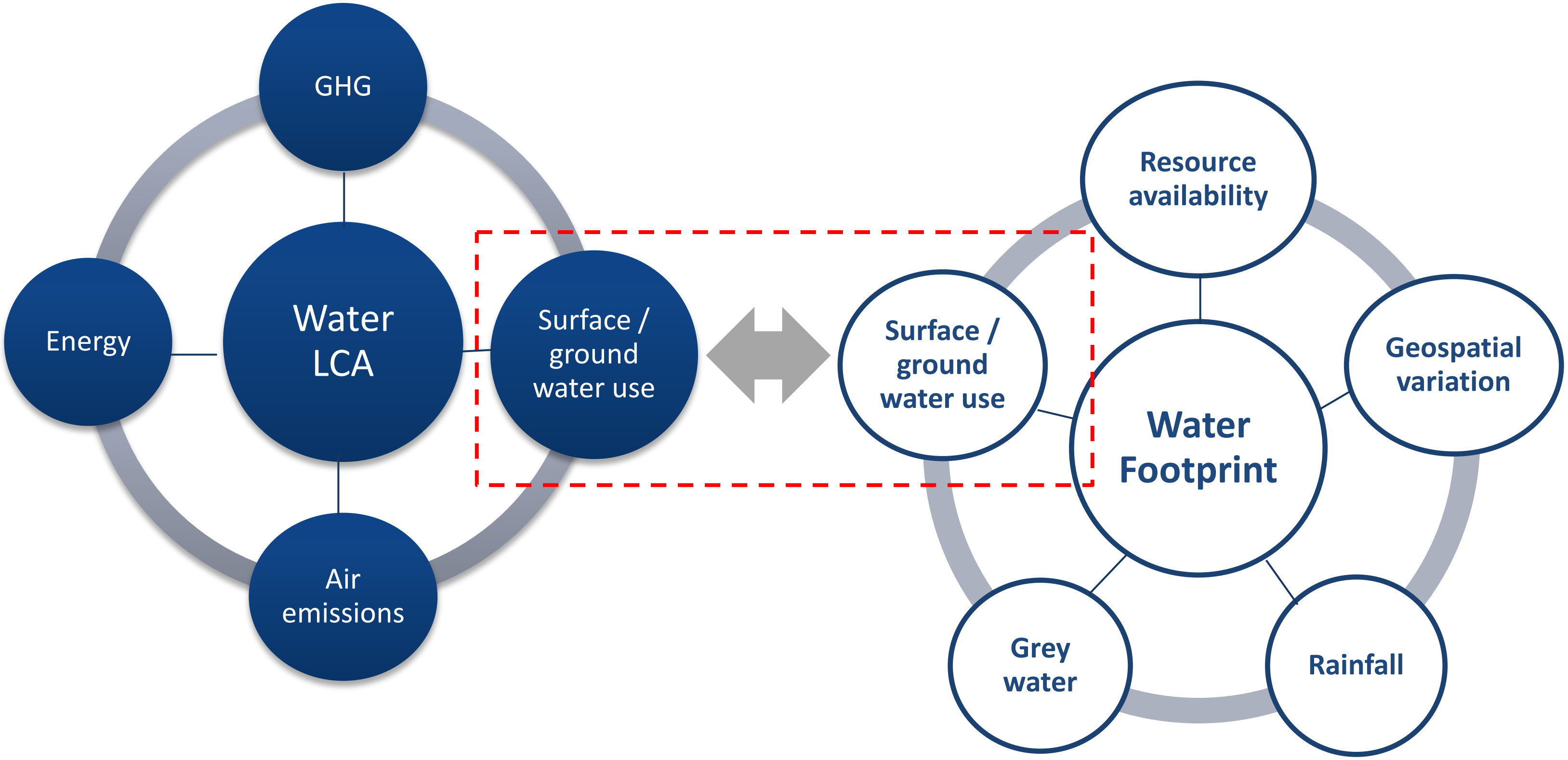


Scope of Water LCA in GREET

- Water consumption is not in current GREET version
- VTO, BETO, and FCTO support incorporation of water consumption in GREET
- VTO task is on fuel-cycle water consumption for baseline fuels and electric power generation for ICEVs, HEVs, PHEVs and BEVs
- GREET evaluates water consumed per MJ of fuel and per mile for various vehicle/fuel systems

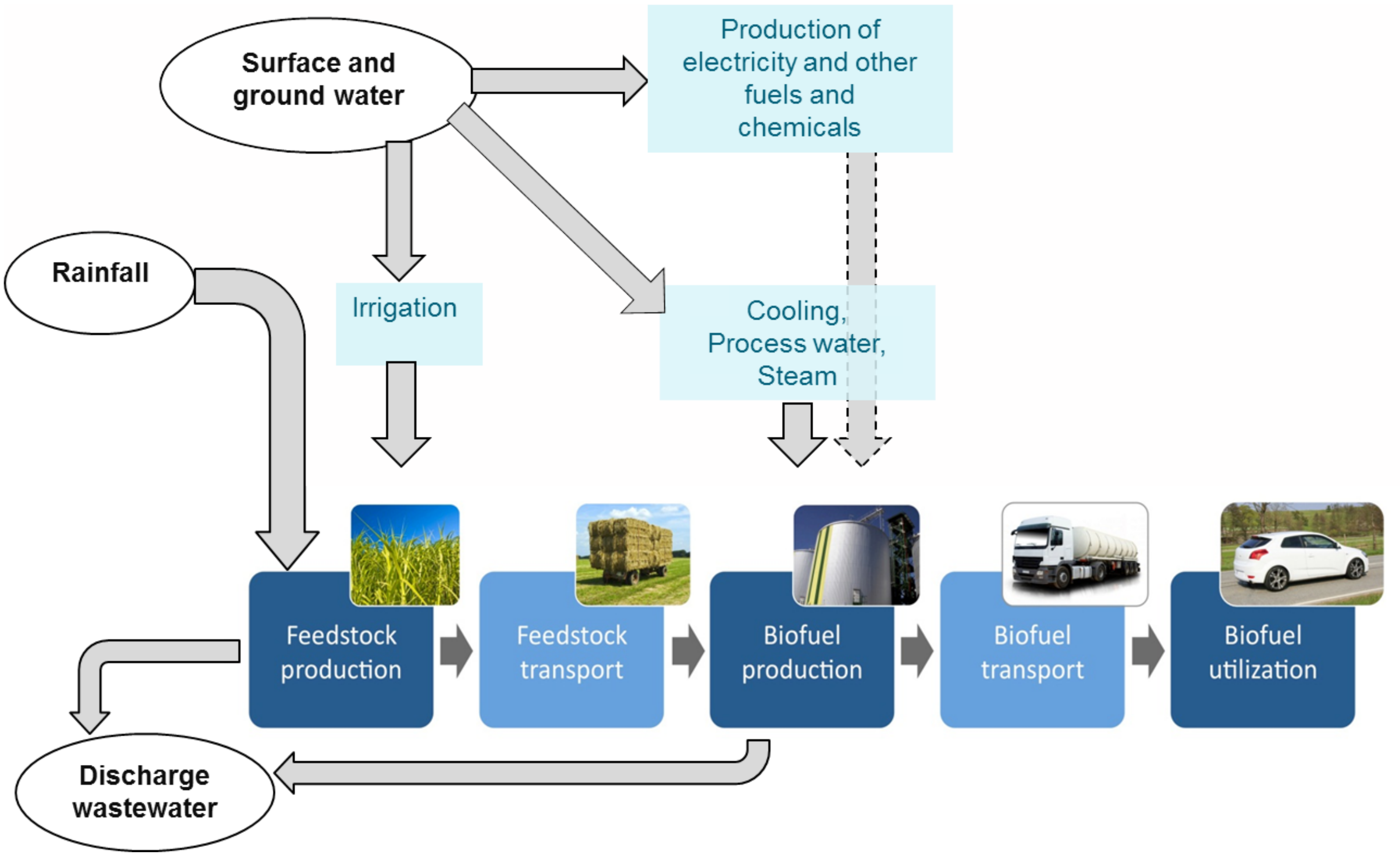


Correlation of Water Footprint Assessment and Water LCA



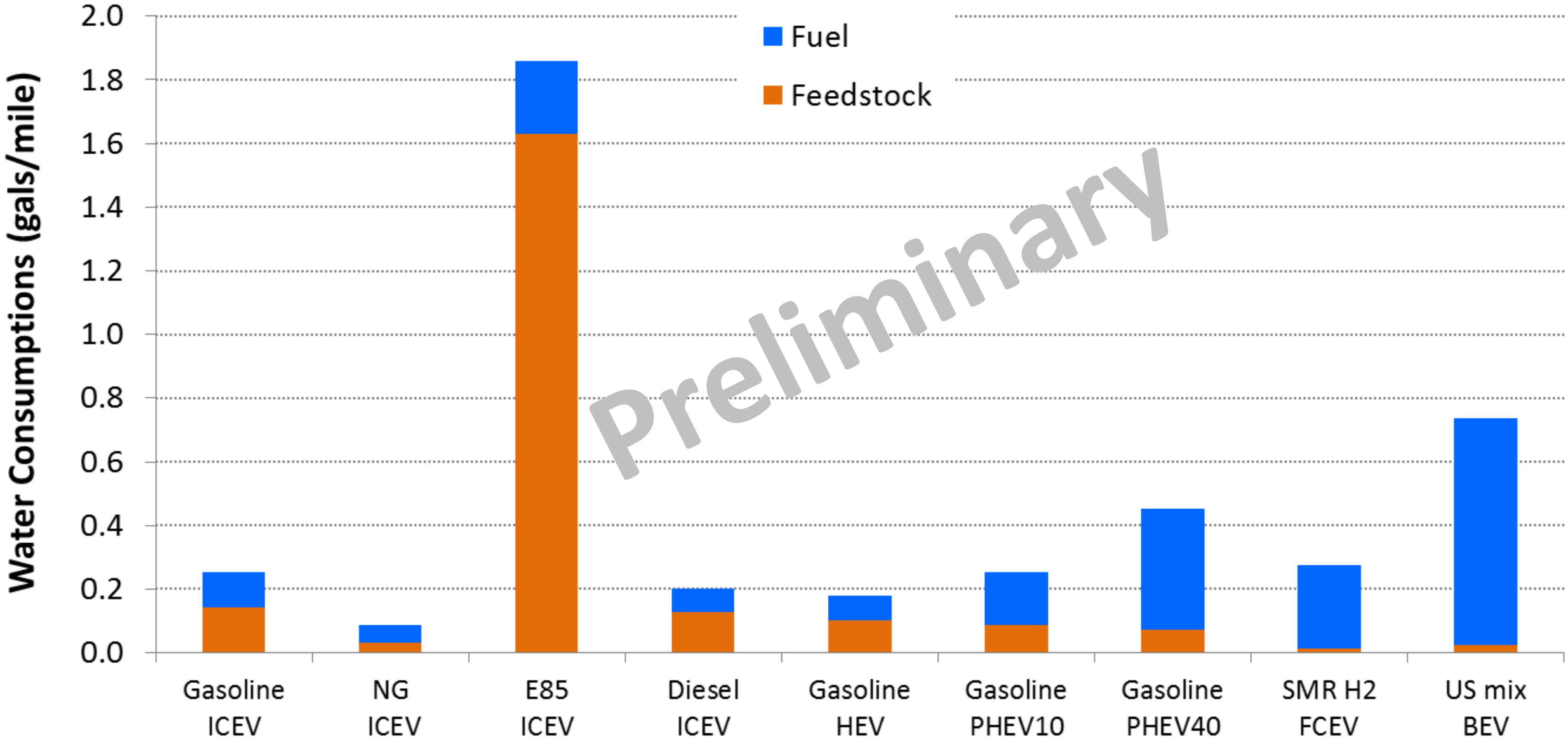
- Water resource (or water footprint) assessment is spatially specific
- Water footprint assessment provides data needed for water LCA
- LCA addresses total water consumption along fuel production pathways

Example: Biofuel Water Use Accounting

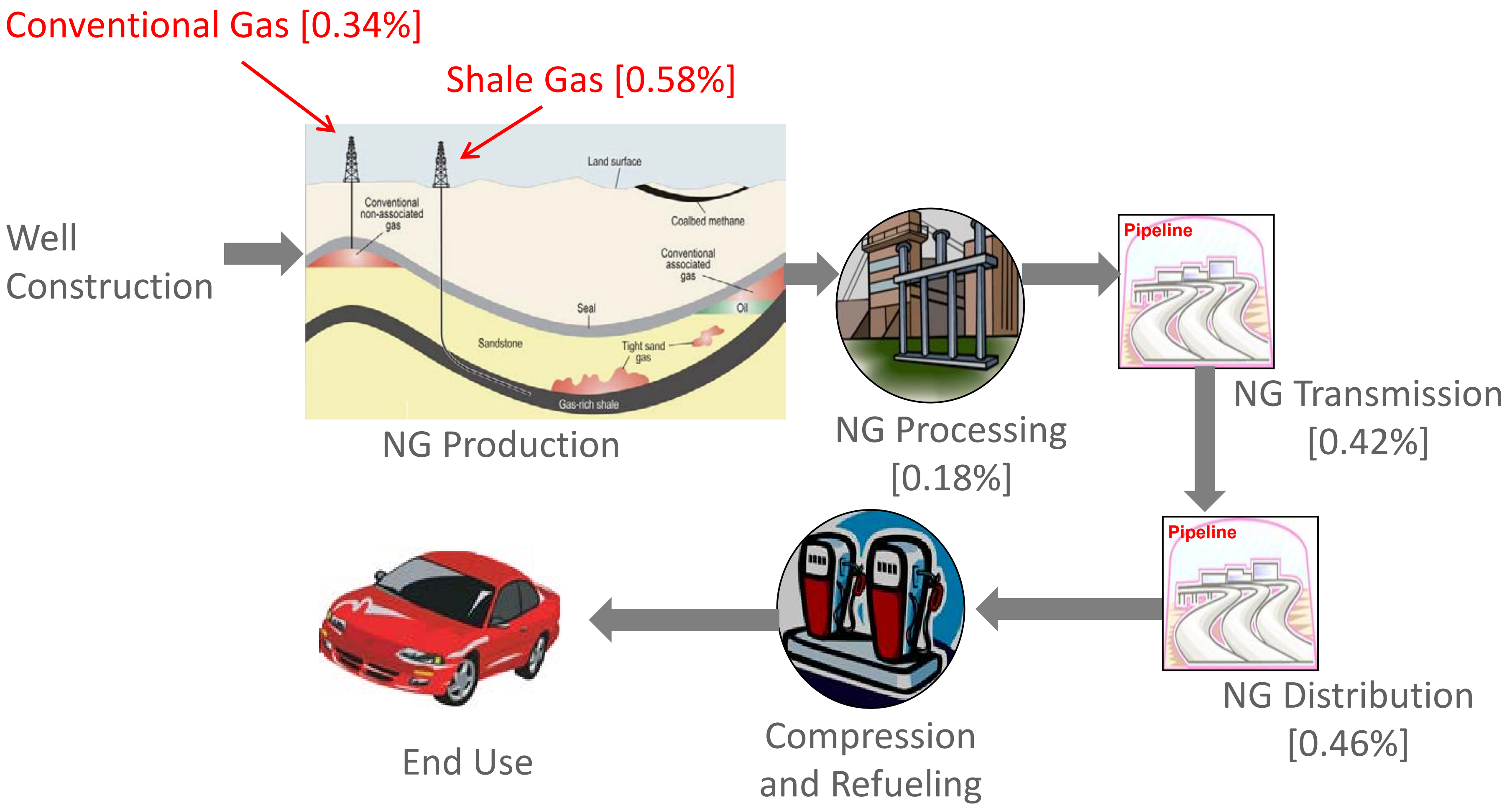


- Water withdrawal: fresh water uptake from surface or groundwater
- Water consumption: net water consumed through the production process (evaporated, rejected or incorporated into the product)

Fuel cycle water consumption varies by feedstock and fuel production technologies (primary pathways)

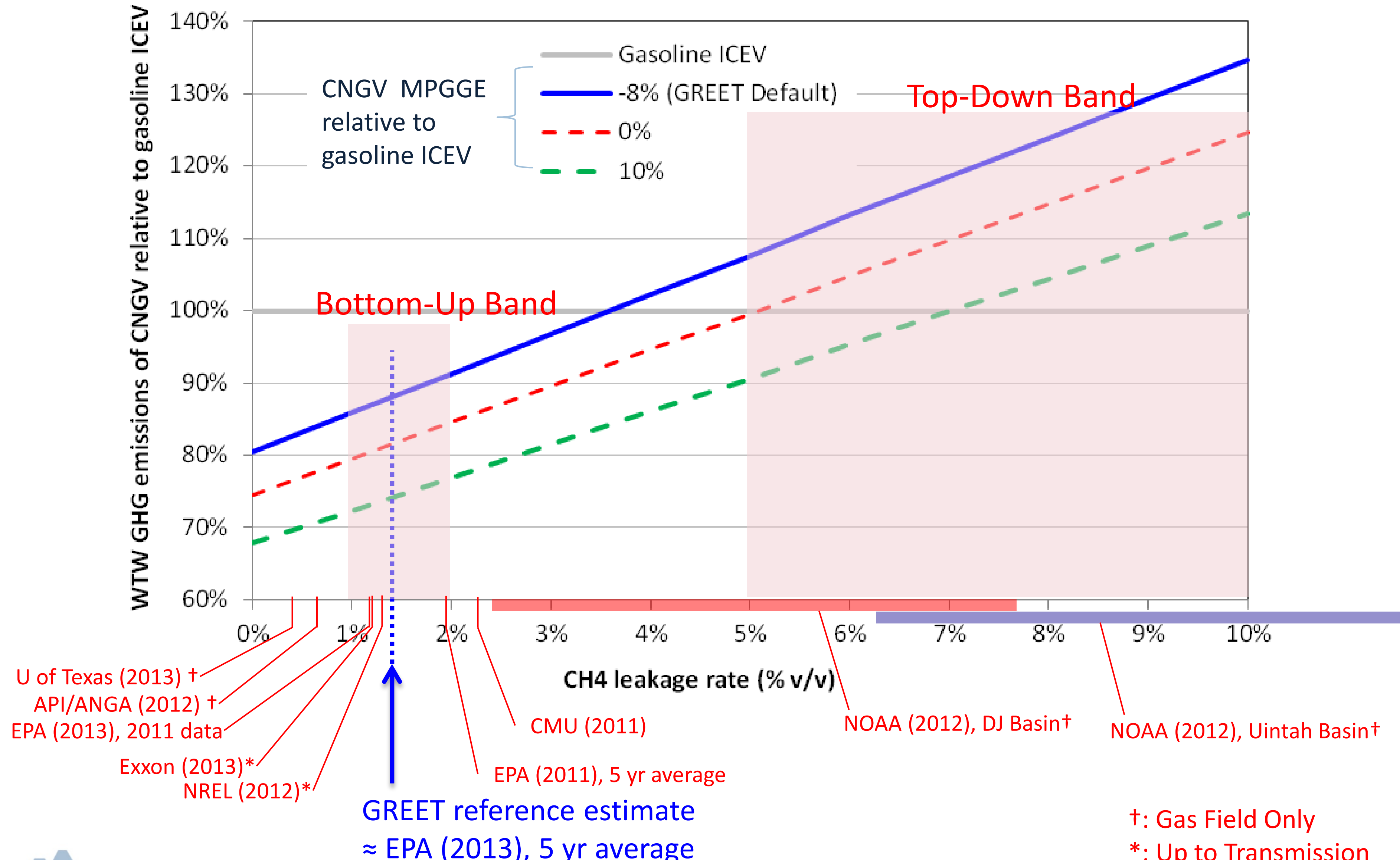


LCA System Boundary: Compressed Natural Gas

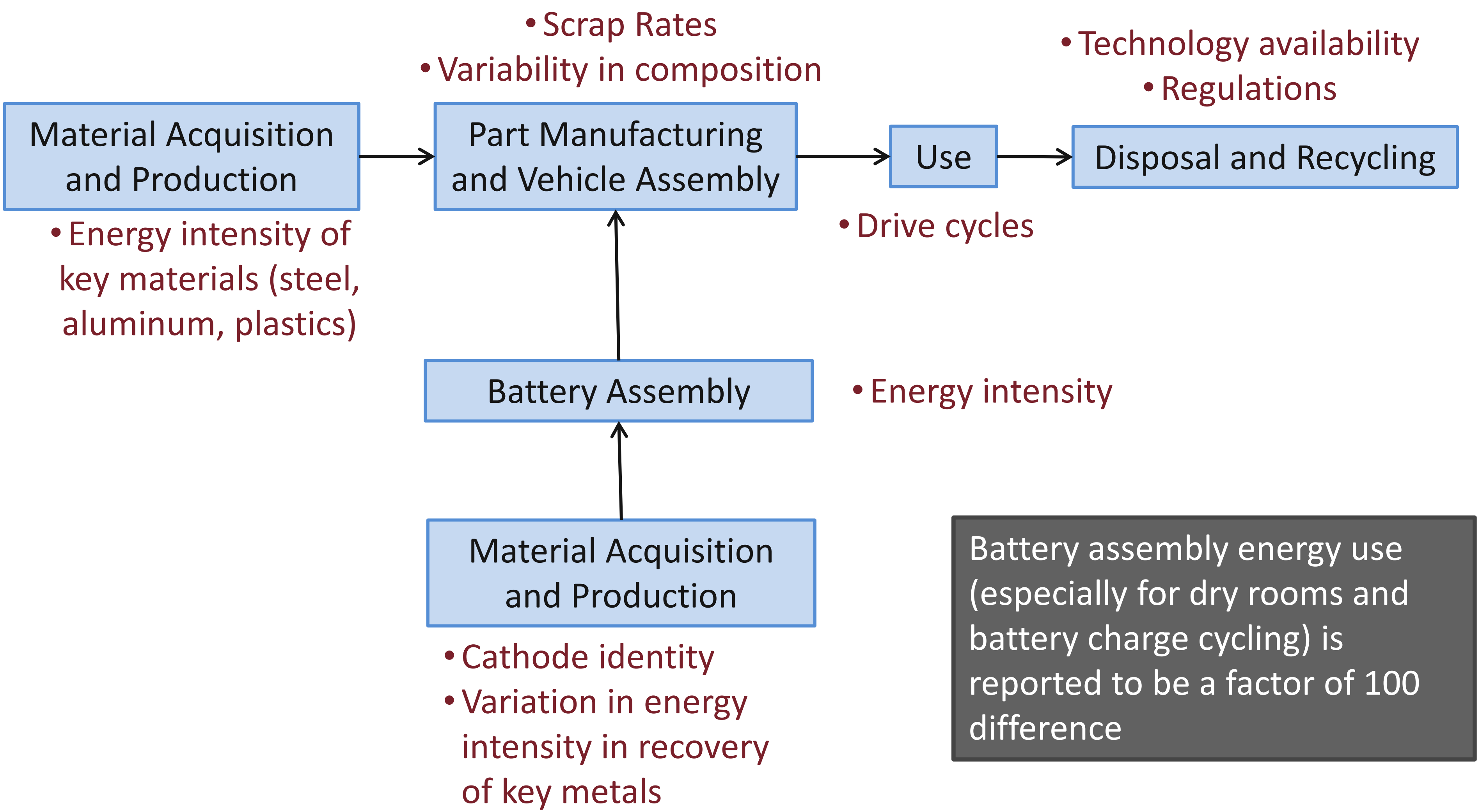


- []: CH4 leakage from each stage by volume
- Emissions from process fuels for recovery, transportation, and compression; and NG combustion
- Infrastructure-related emissions are usually small

WTW GHG Emissions of CNG Vehicles vs. Gasoline Vehicles - Methane Leakage and CNGV Efficiency are Two Key Factors



Key Issues in the Vehicle Manufacturing Cycle



Battery assembly energy use (especially for dry rooms and battery charge cycling) is reported to be a factor of 100 difference

For GREET model and technical reports, please visit

greet.es.anl.gov