ARGONNE NATIONAL LABORATORY

TRANSPORTATION TECHNOLOGY R&D CENTER

Integration of the GREET Model into MOVES

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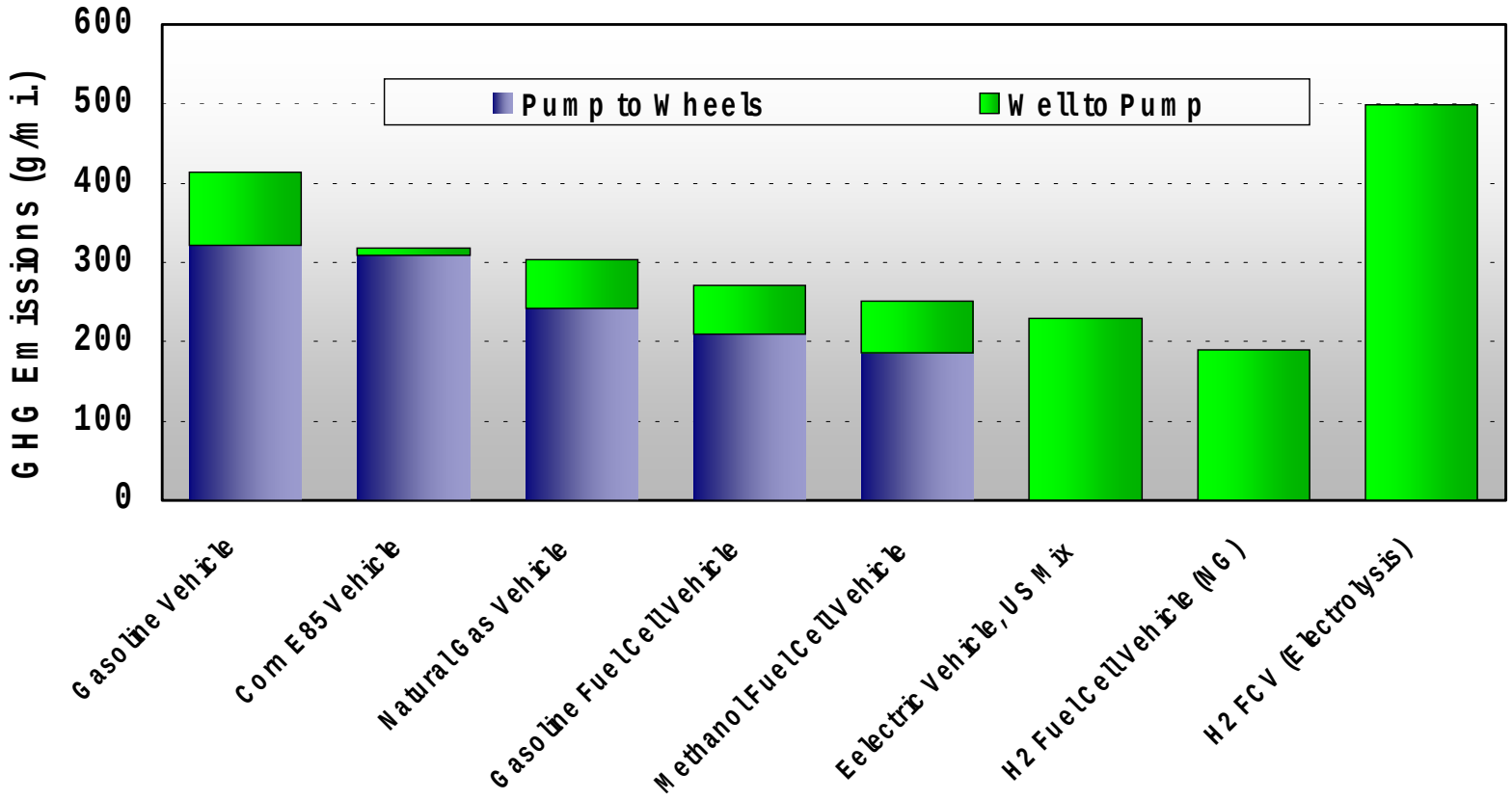
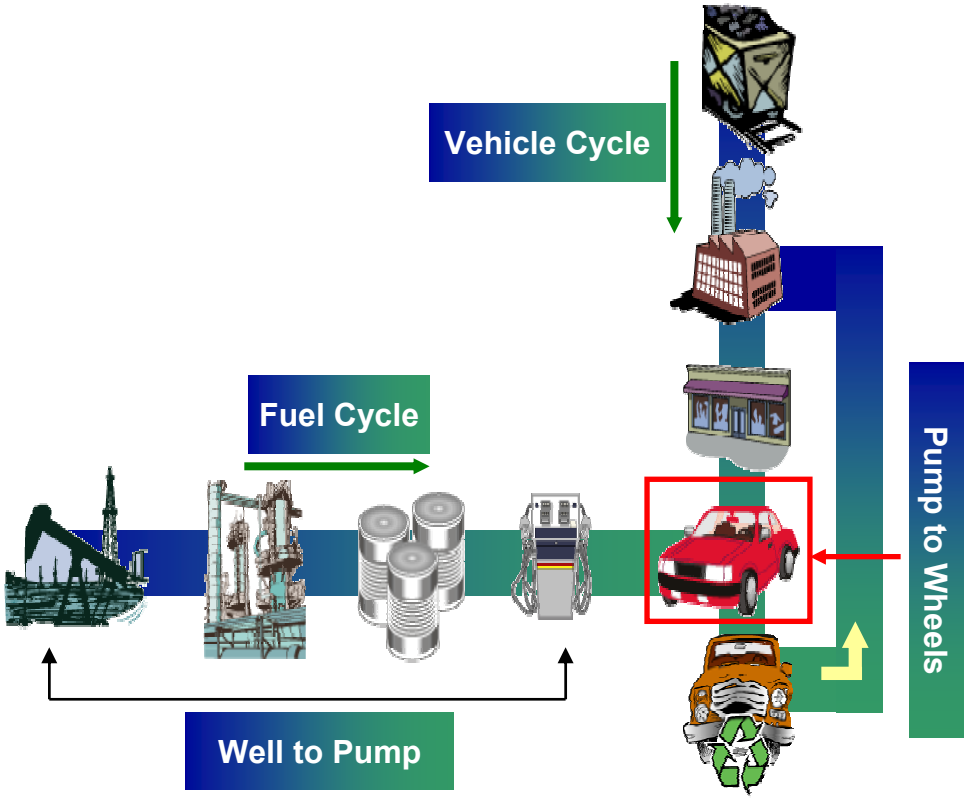
WTW Analysis Is a Complete Energy/Emissions Comparison

As an example, greenhouse gases are illustrated here



With DOE Support, Argonne Developed the GREET Model for Well-to-Wheels Analysis

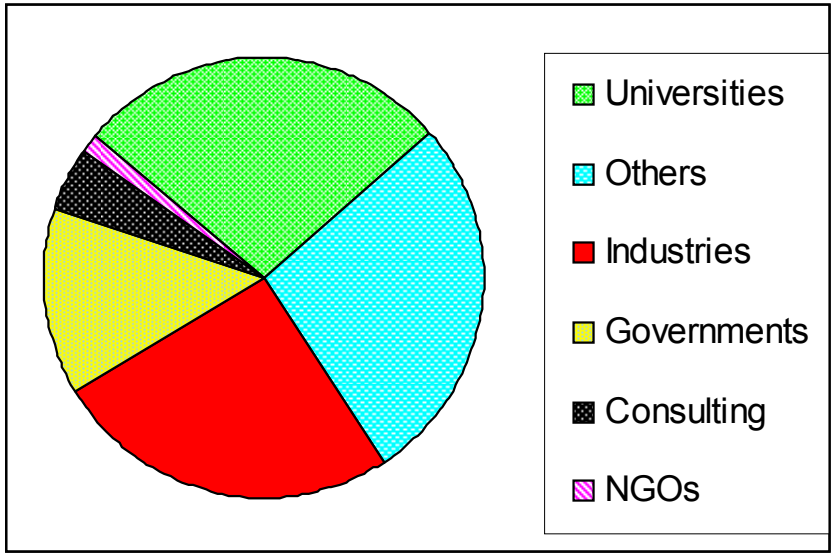


Key GREET features

- Emissions of greenhouse gases
  - ✓ CO_2, CH_4, and N_2O
- Energy use
  - ✓ All energy sources
  - ✓ Fossil fuels (petroleum, NG, coal)
  - ✓ Petroleum
- Emissions of five criteria pollutants
  - ✓ Total and urban separately
  - ✓ VOC, CO, NO_x, SO_x, and PM_{10}

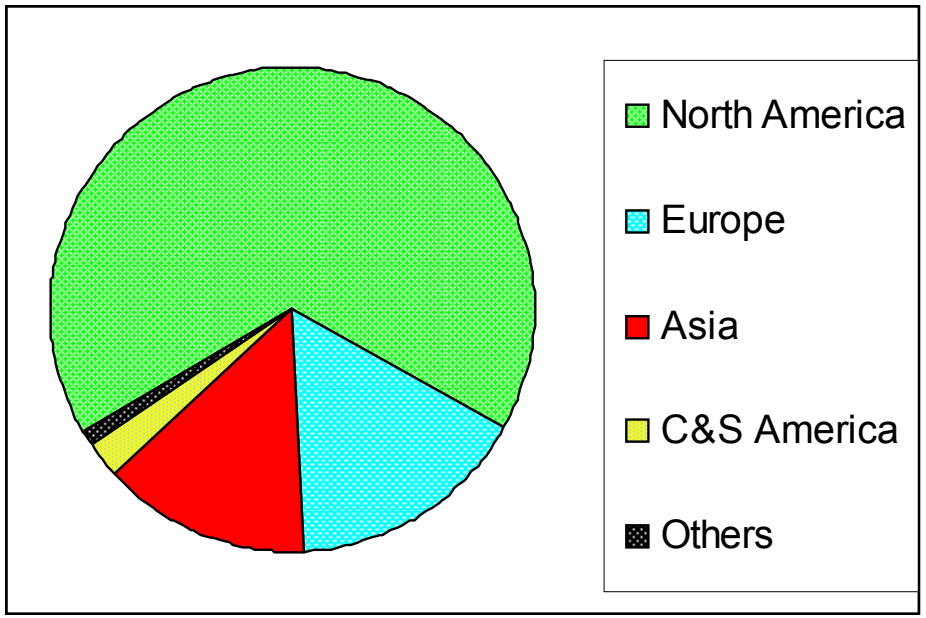
GREET and its documents are available at
http://www.transportation.anl.gov/software/GREET/index.html

At Present, There Are More Than 1,700 GREET Registered Users Worldwide



GREET users are primarily in universities, industries, and governments

They are primarily in North America, Europe, and Asia



Integration of GREET into MOVES Has Been a Joint Effort Between EPA and DOE

- EPA focus: GREET/MOVES integration
  - GREET well-to-pump + MOVES pump-to-wheels
  - Seamless programming integration of two models
- DOE focus: add new fuel production pathways
  - Coal Gasification to H2
  - Nuclear energy to H2
  - Biomass gasification to H2
  - Gasoline and diesel from Canadian oil sands
- The integration effort completed so far was for energy use and GHG emission modeling

Time Series Based Simulations Were Added To GREET Through This Effort

- Previous GREET versions were based on two snap-shot simulations
  - Near term
  - Long term
- New GREET version can simulate a target year
  - Between 1990 and 2020
  - Technology advancement over time is established with time-series look-up tables in GREET
- Users can conduct simulations over time by using values for key parameters
  - GREET default values in look-up tables
  - User-specified values over time
  - GREET interpolation and extrapolation of partial inputs from users

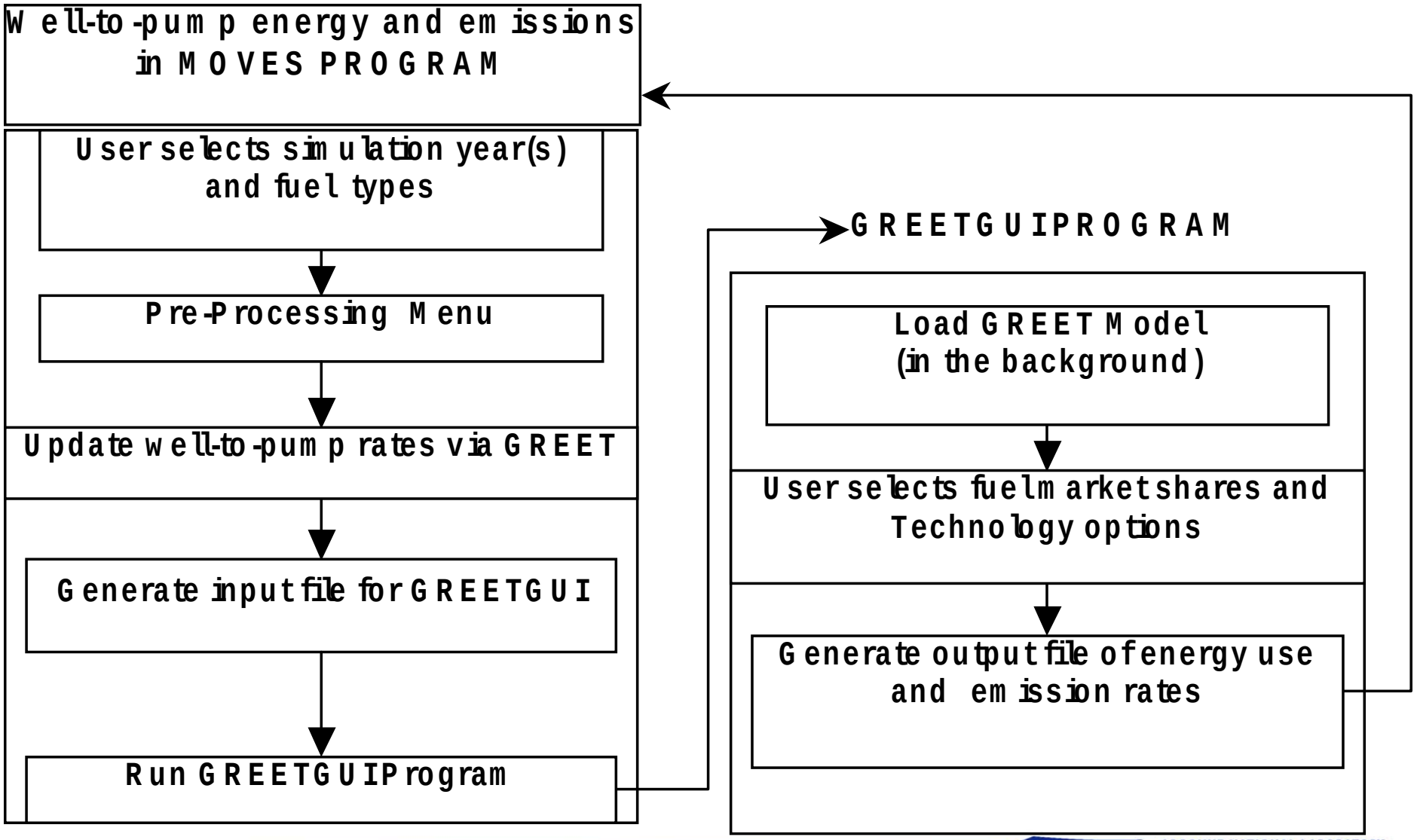
For a Given Fuel, the New GREET Version Combines Production Options with Market Shares

- Previous GREET versions conducted simulations for a fuel's production options exclusive to each other
- The new version combines different production options with their potential market shares
- As an example, users can generate one set of results for the following H2 production options combined with their potential market shares

NG central SMR	NG distributed SMR	Nuclear H2
Biomass H2	Coal H2	Electrolysis H2
Solar PV H2	MeOH/EtOH to H2 at refueling stations	

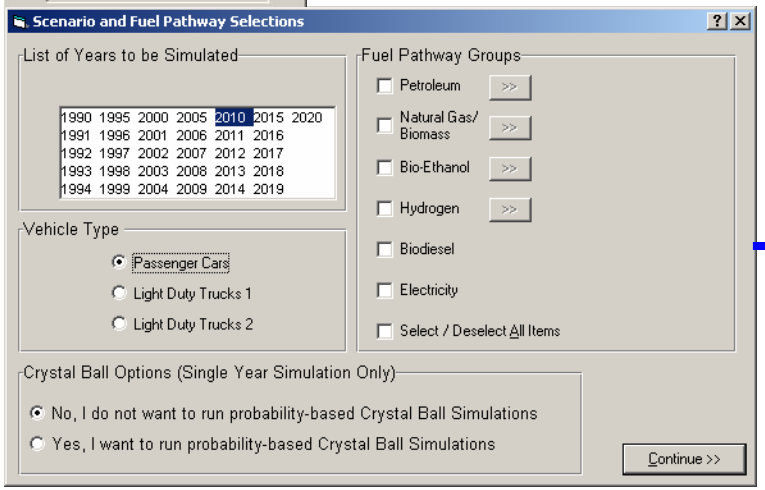
- But users can still simulate a single production option by assigning 100% market share to it

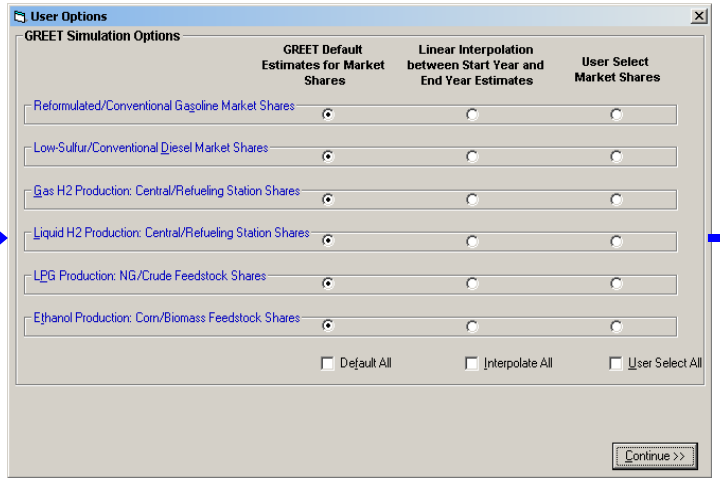
Simulation Steps of Integrated GREET/MOVES

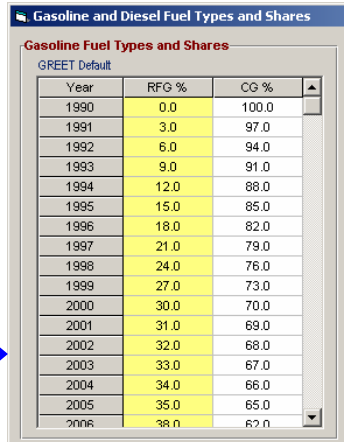


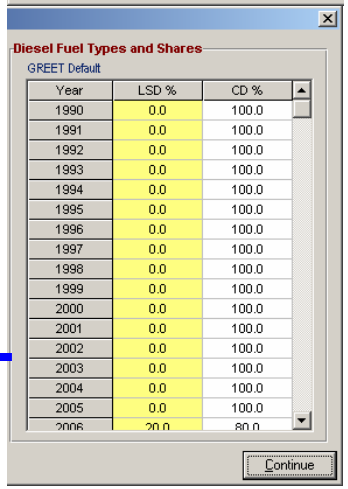
GREETGUI Designs for GREET/MOVES Integration

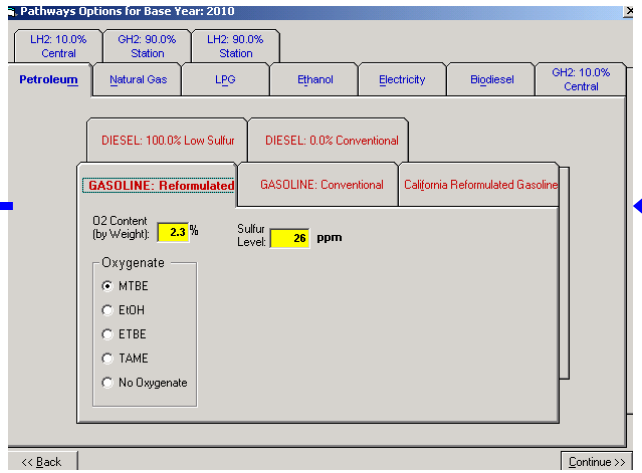
From MOVES

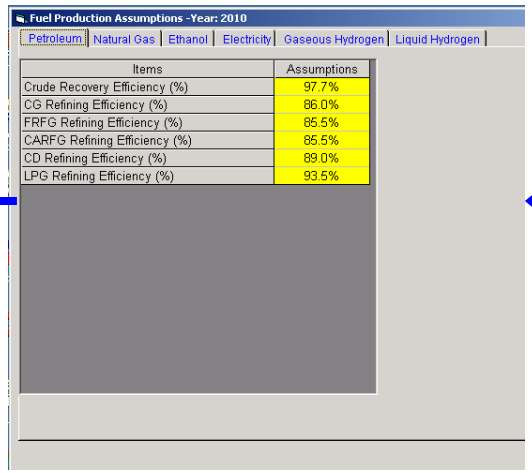


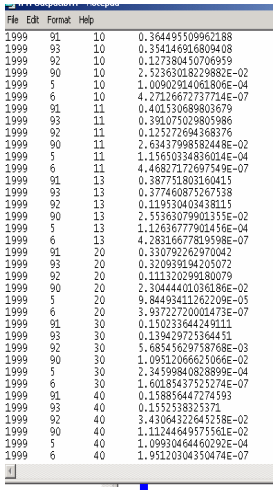












Back to MOVES

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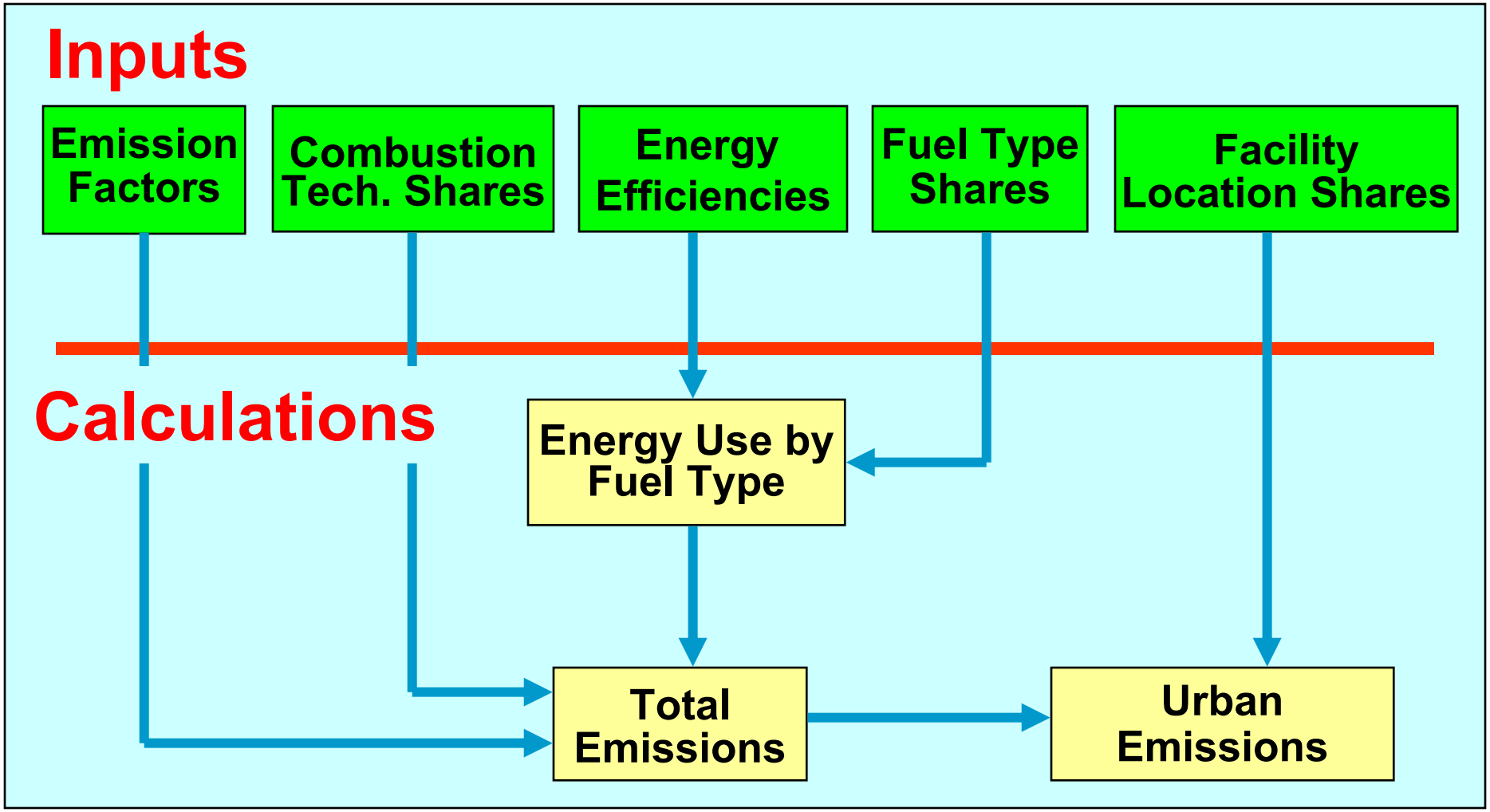
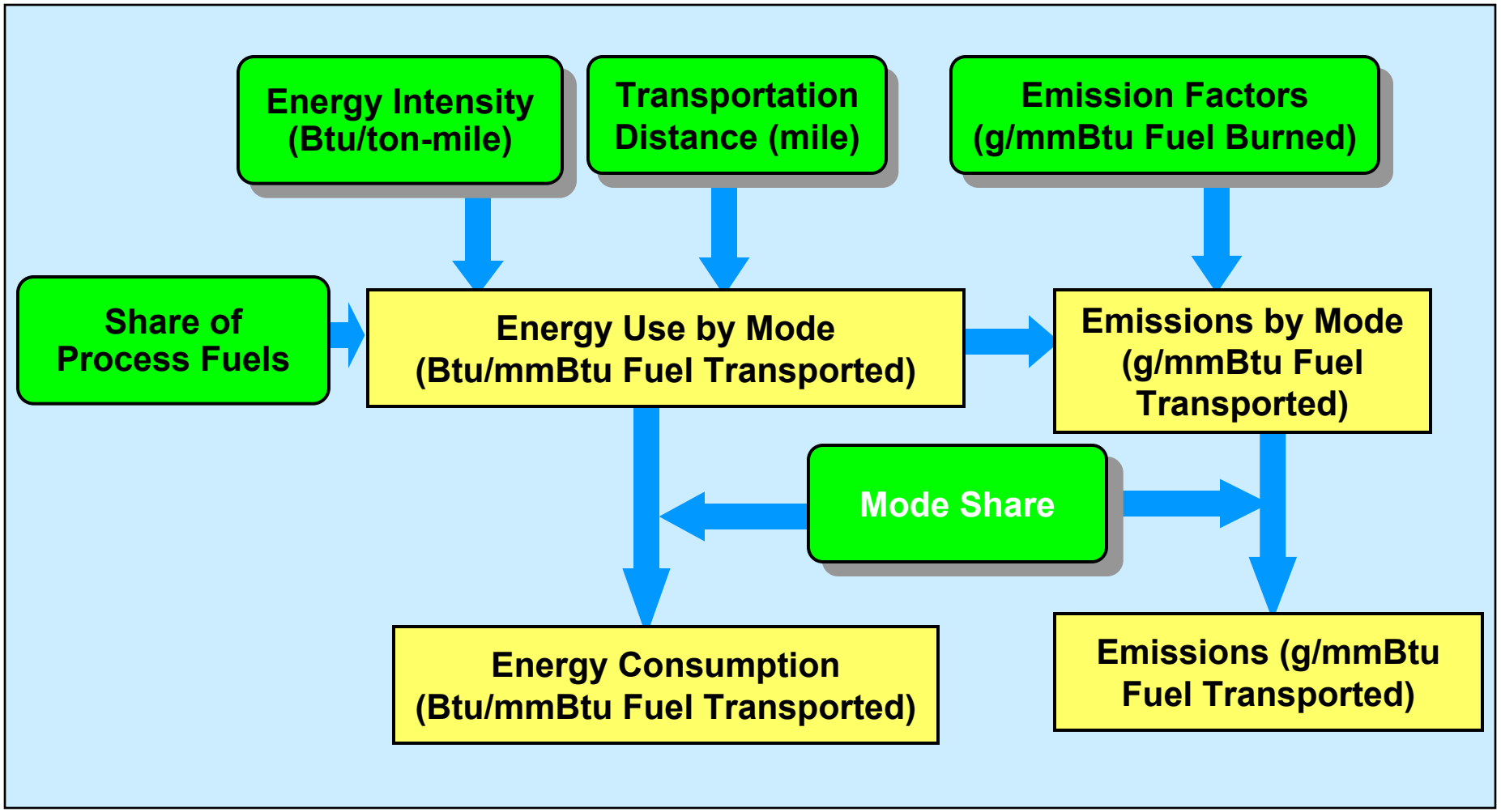
Calculation Logic for a Given WTP Production Activity in GREET

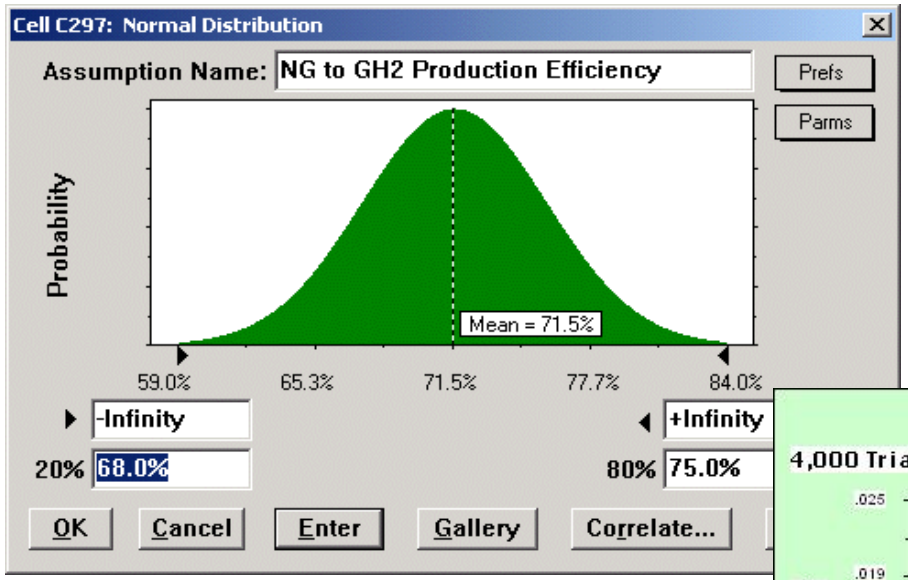


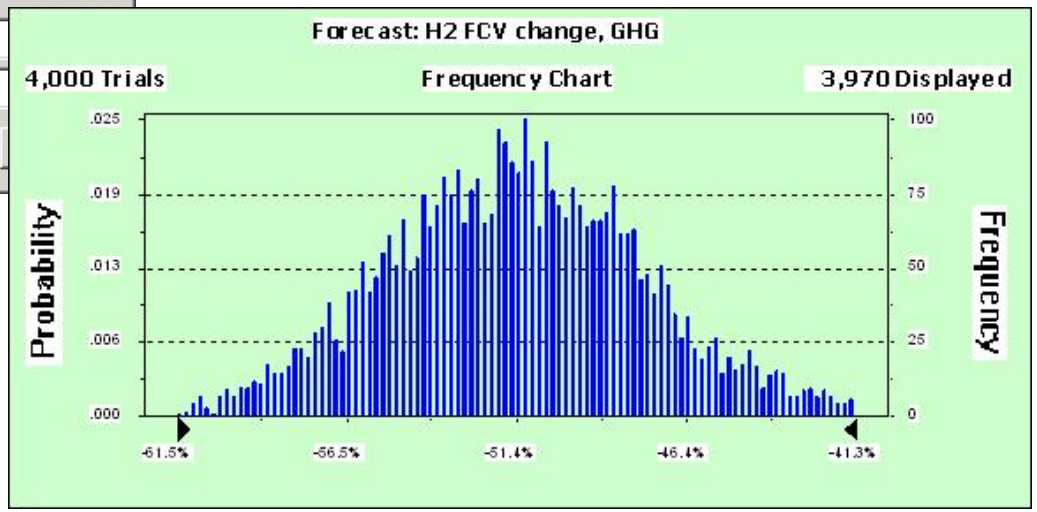
Calculation Logic for a Given WTP Transportation Activity in GREET



GREET Is Designed to Conduct Stochastic Simulations

Distribution-Based Inputs Generate Distribution-Based Outputs

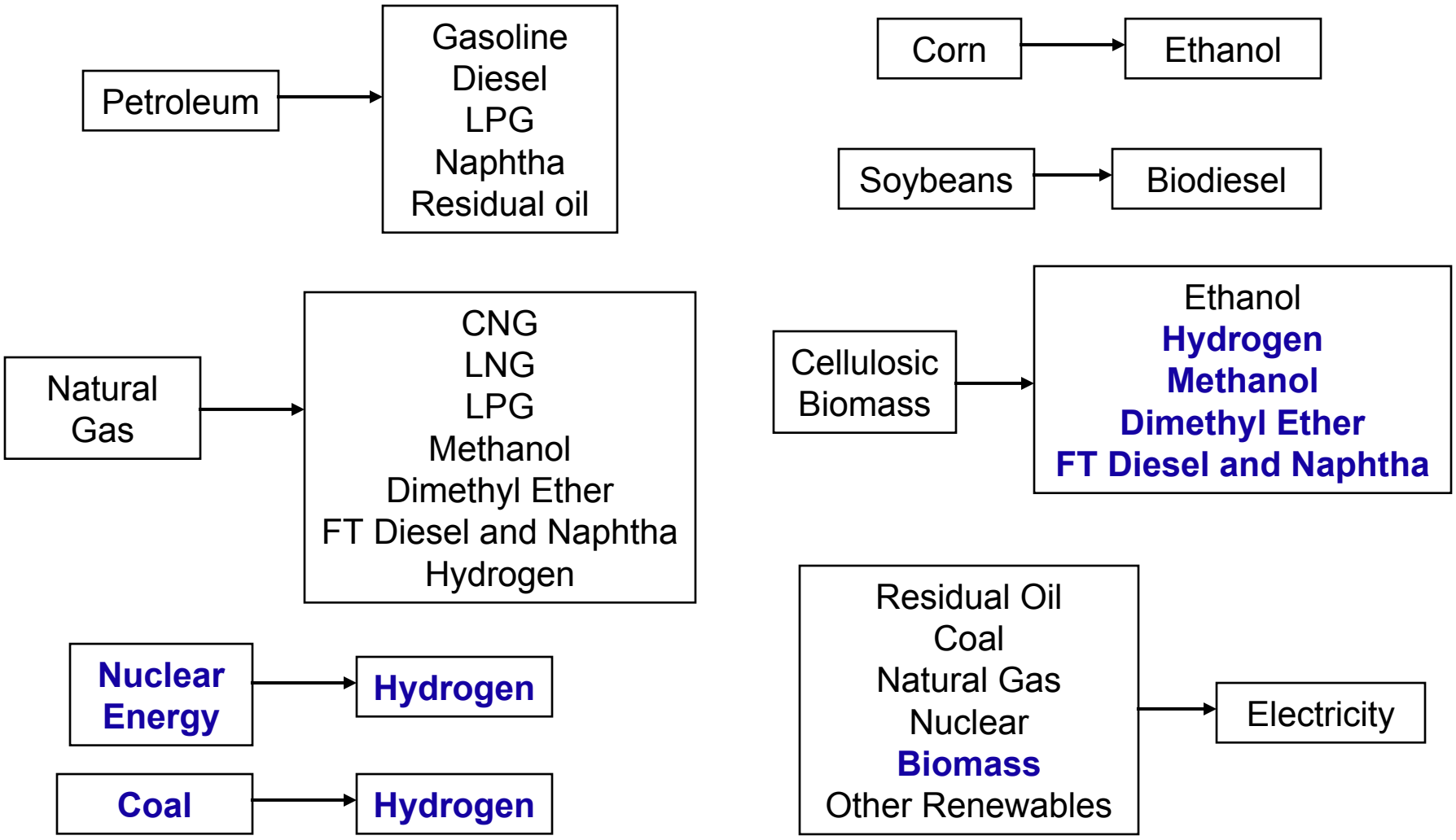




WTP Criteria Pollutant Issues Were Addressed Through A Project with GM

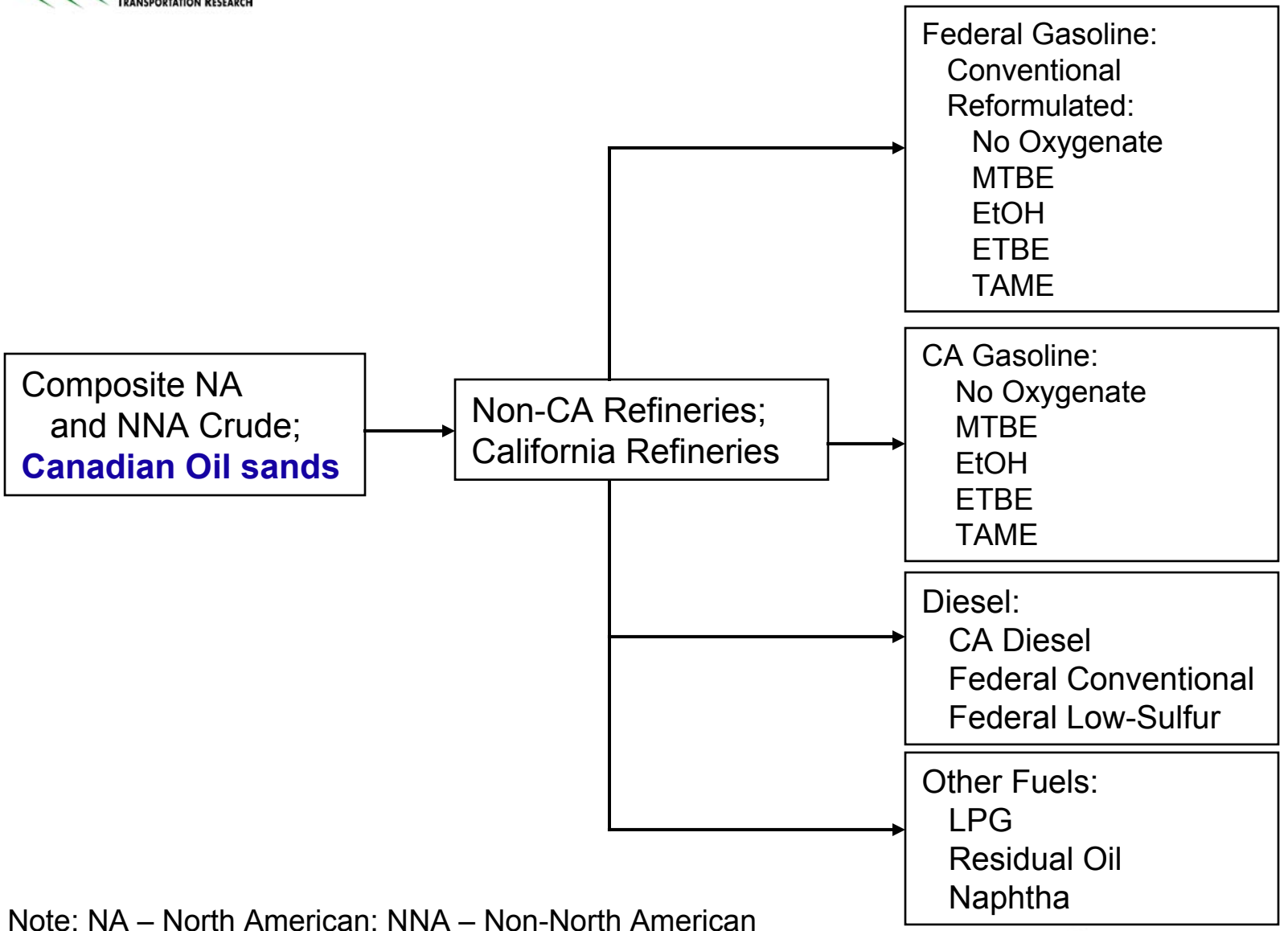
- Data for relevant facilities were extracted from EPA's 1999 National Emissions Inventory database
- Total emissions for a given facility were divided by its throughput to develop emissions factors
- Distribution curves were fitted to current EPA emission data
- The curves were further adjusted to account for improvements by future technologies and emission controls

GREET Includes Transportation Fuels from Various Energy Feedstocks



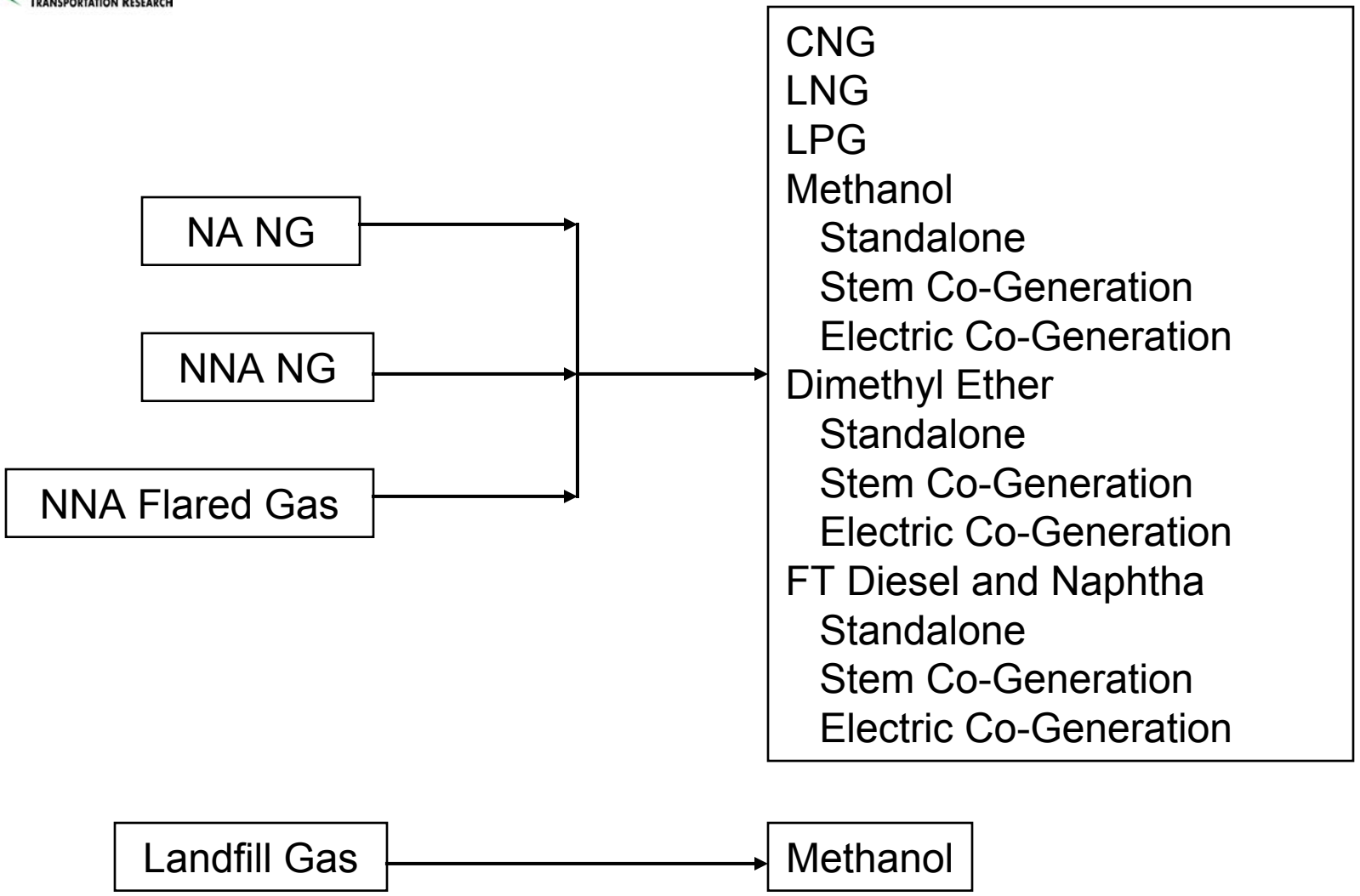
Note: options in blue are new.

GREET Petroleum Fuel Pathways



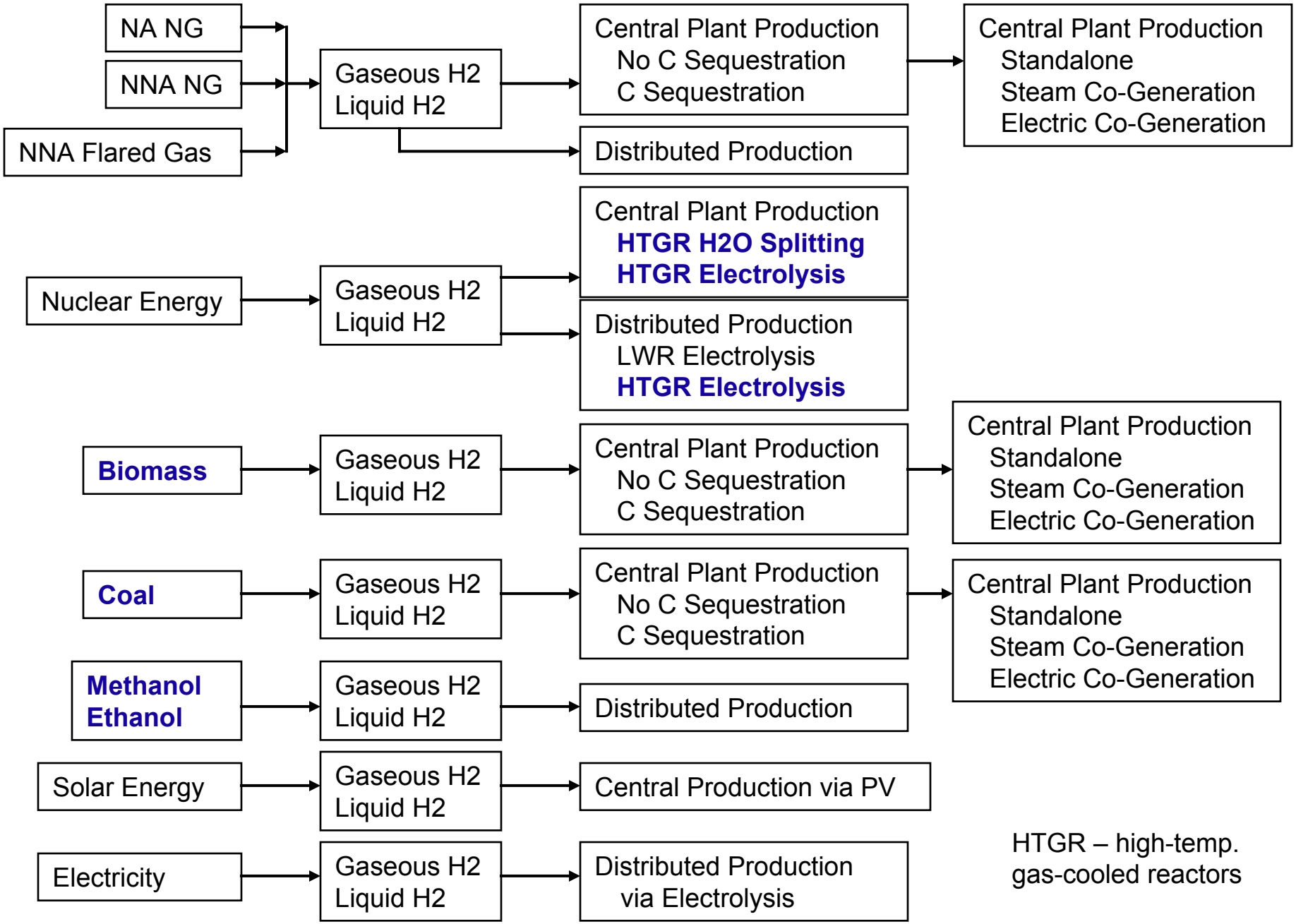
Note: NA – North American; NNA – Non-North American

GREET Natural Gas Fuel Pathways



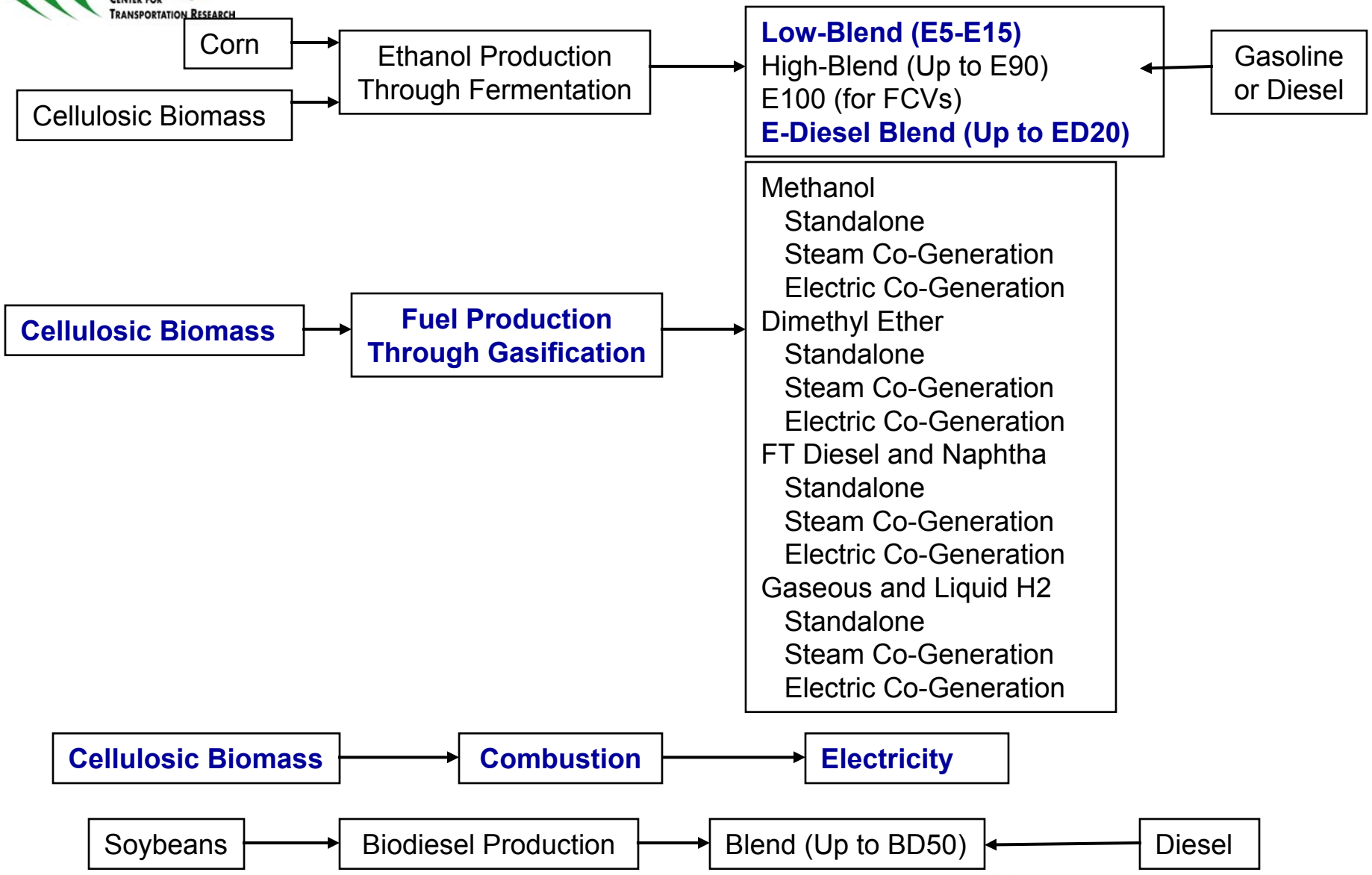
Note: hydrogen from NG options are not presented here.

GREET Hydrogen Production Pathways

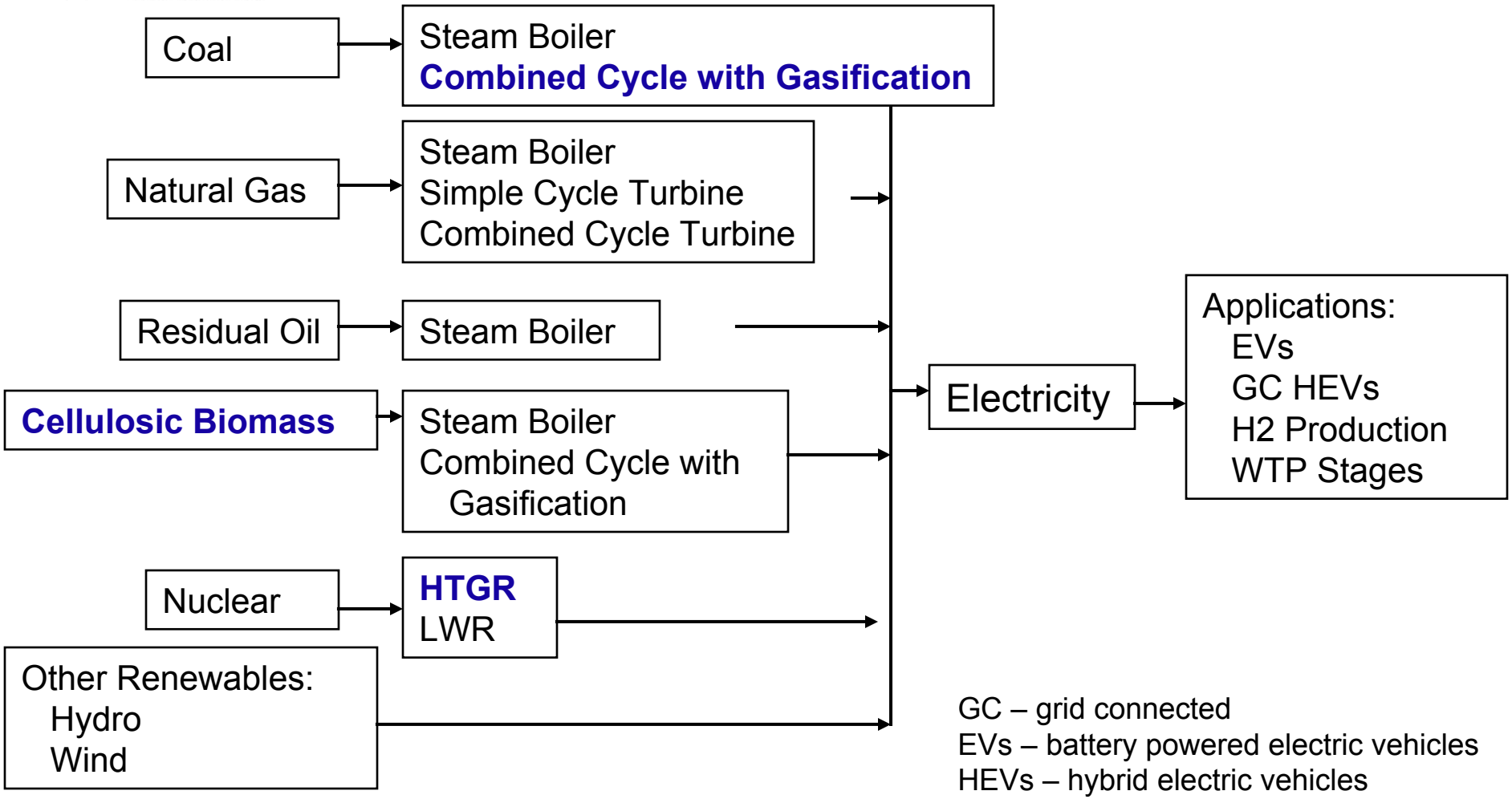


HTGR – high-temp. gas-cooled reactors

GREET Includes a Variety of Biofuel Pathways

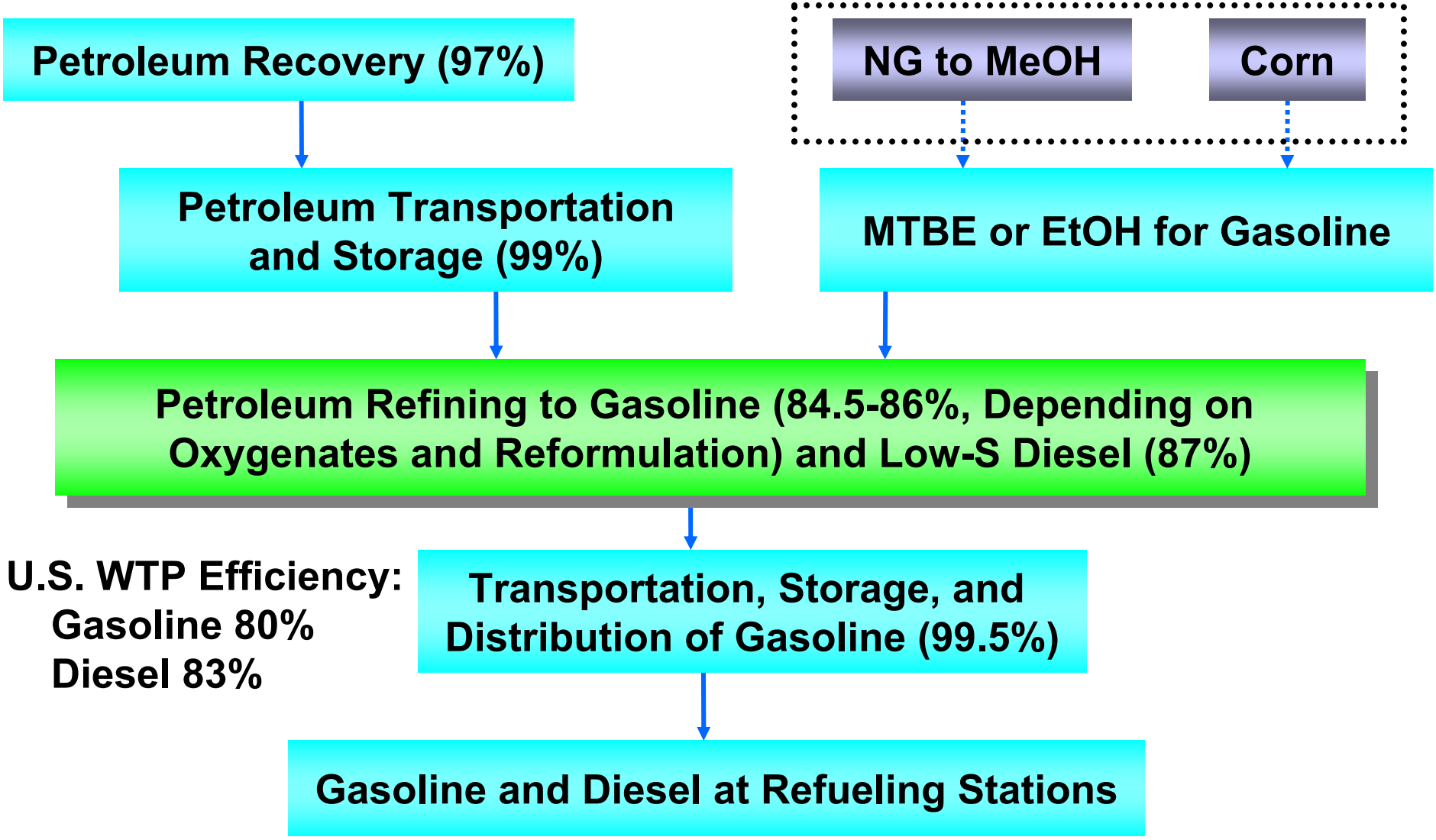


GREET Electricity Generation Pathways

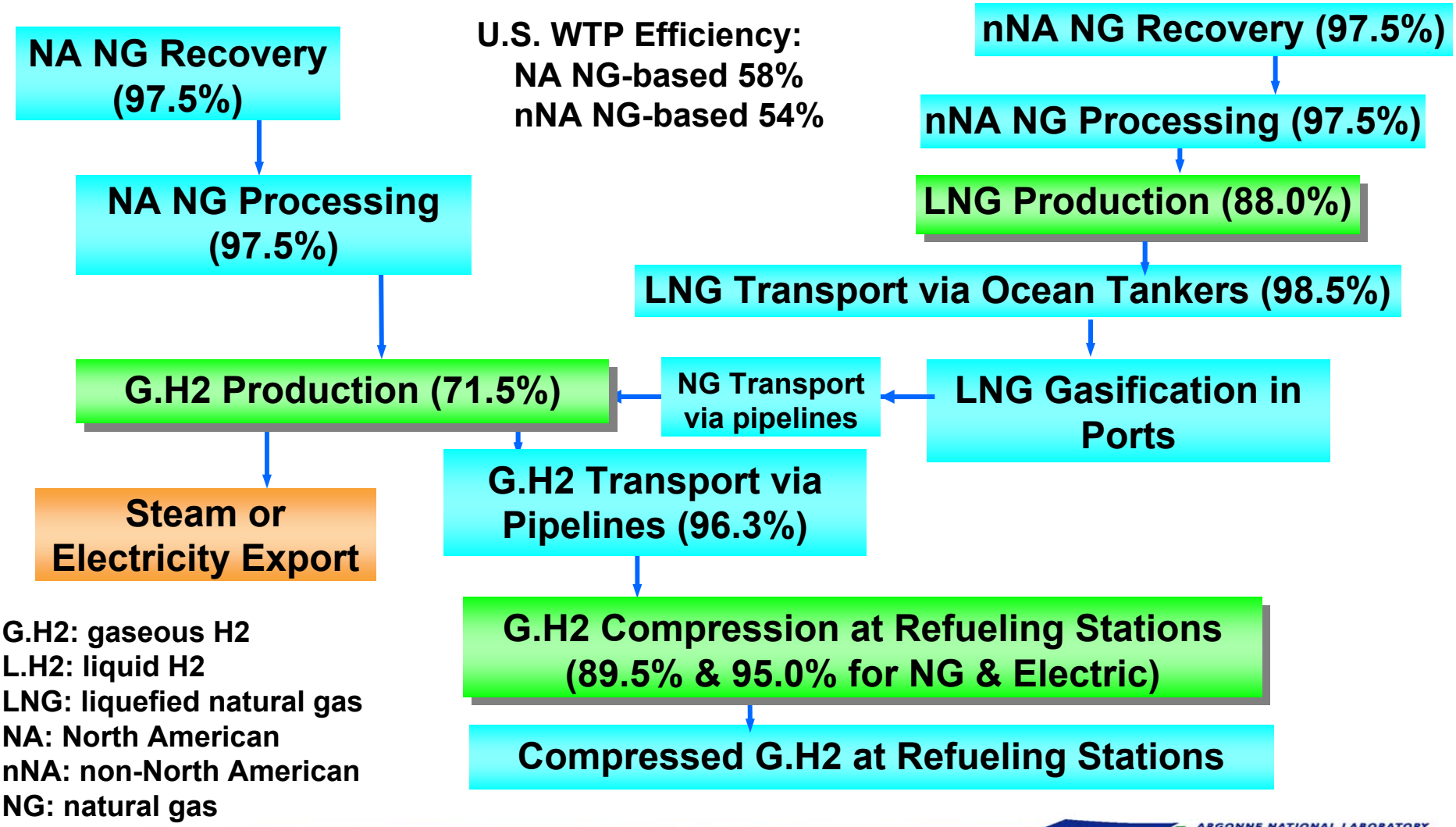


GC – grid connected
EVs – battery powered electric vehicles
HEVs – hybrid electric vehicles
WTP – well to pump
HTGR – high-temp. gas-cooled reactors
LWR – light water reactors

Petroleum Refining Is the Key Energy Conversion Step for Gasoline and Diesel

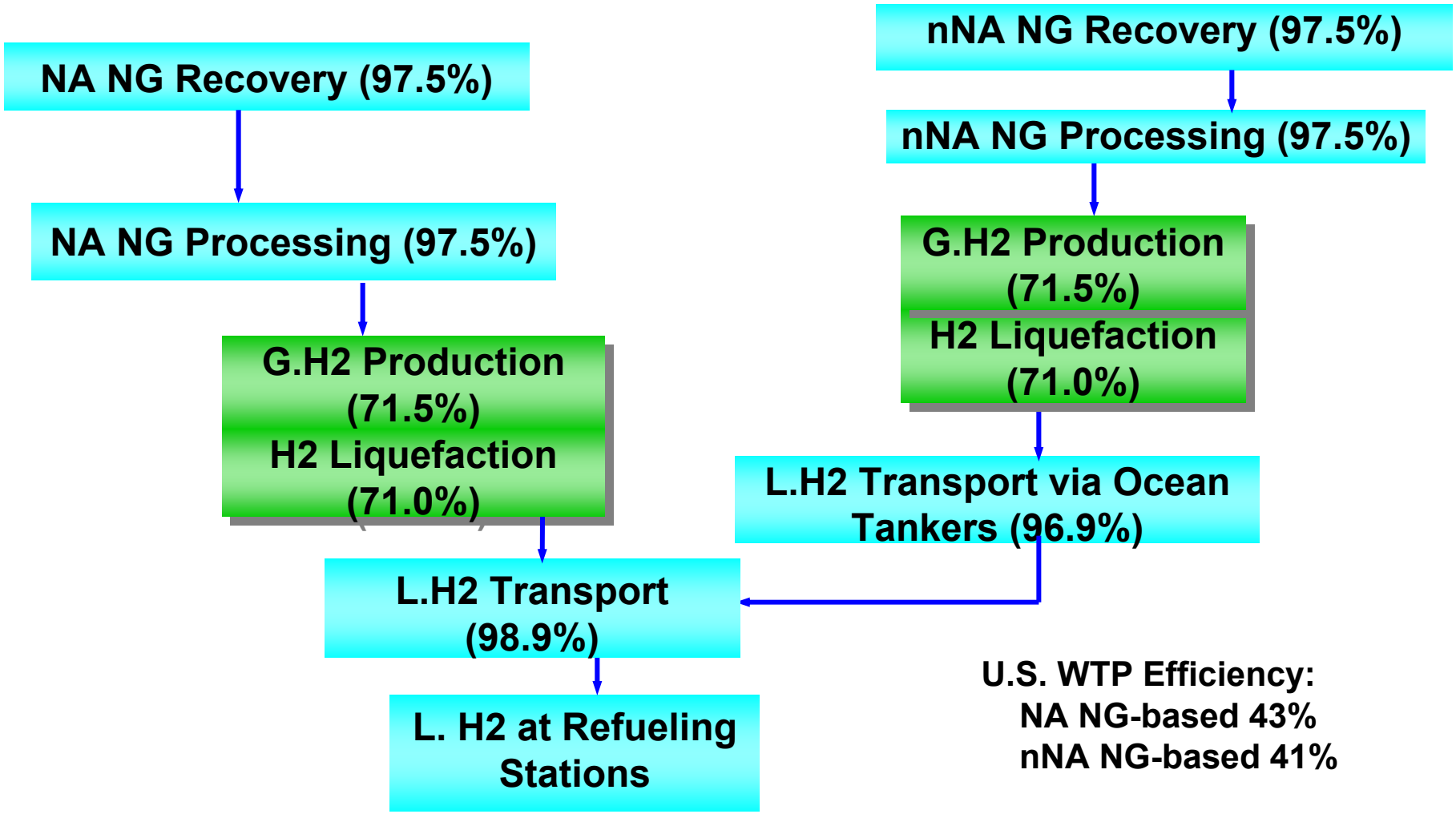


Production and Compression Are Key Steps for G.H$_2$ Production



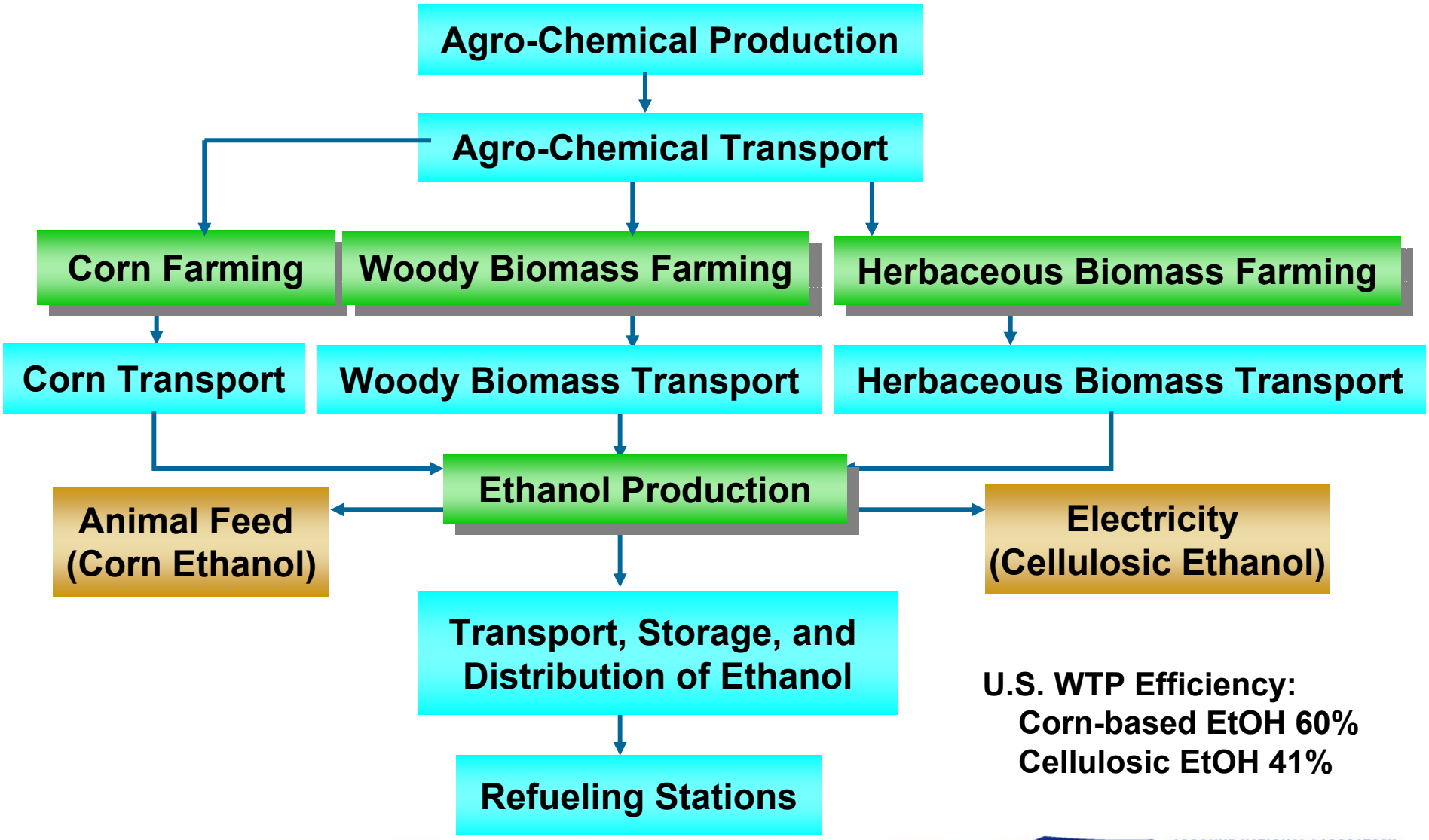
G.H2: gaseous H2
L.H2: liquid H2
LNG: liquefied natural gas
NA: North American
nNA: non-North American
NG: natural gas

H_2 Liquefaction Has Higher Energy Losses Than H_2 Compression



U.S. WTP Efficiency:
NA NG-based 43%
nNA NG-based 41%

Ethanol WTP Pathways Include Activities from Fertilizer to Ethanol at Stations

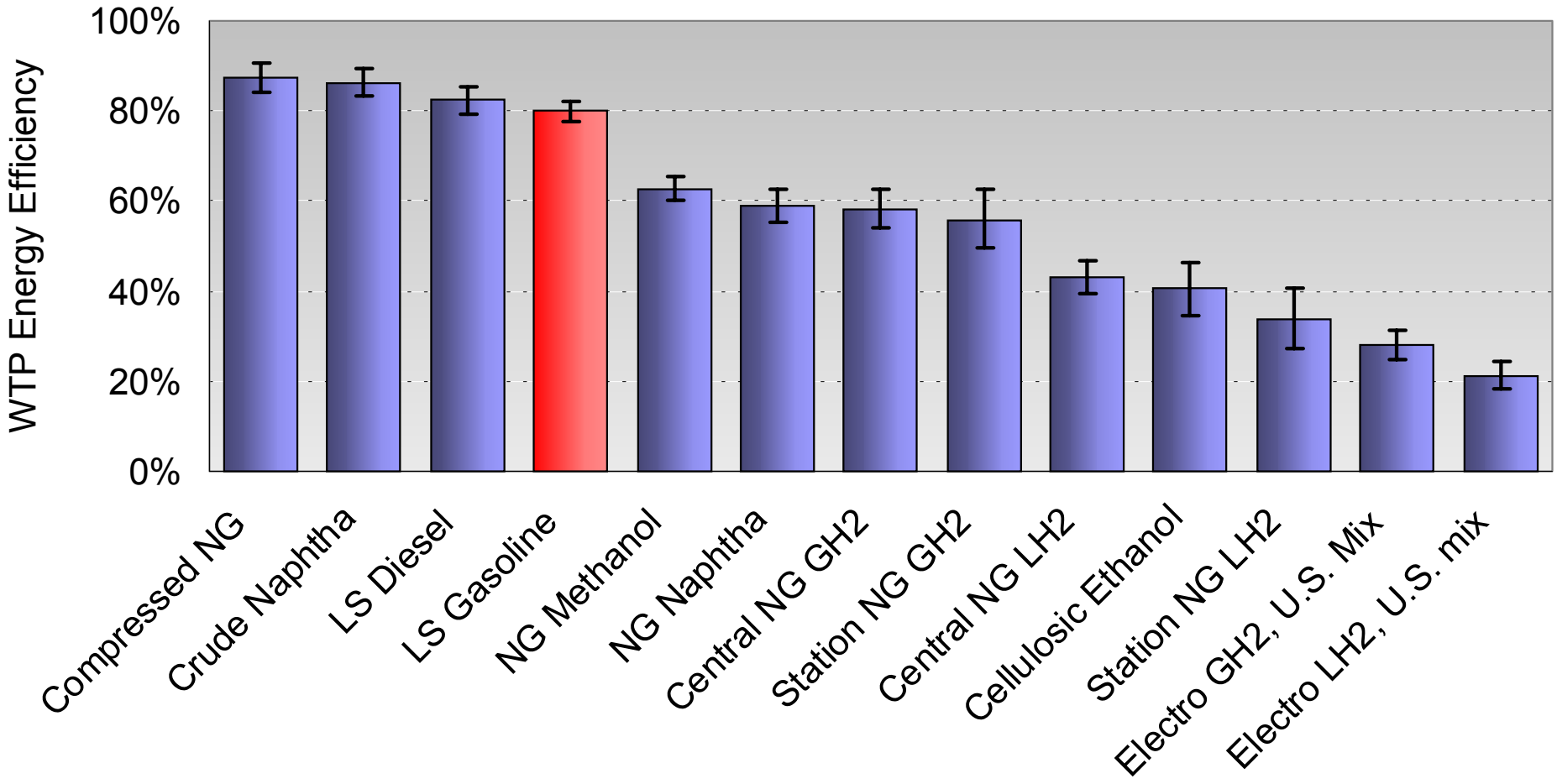


U.S. WTP Efficiency:
- Corn-based EtOH 60%
- Cellulosic EtOH 41%

Users of GREET/MOVES Need to Pay Close Attention to Key Input Parameters

- GREET WTP default assumptions are U.S. averages
- Scope and assumptions for individual states/regions could differ significantly
  - Transportation fuel types for simulations
  - Fuel production options for a given fuel (such as electricity generation and reformulated gasoline production)
  - Market shares of production options for a given fuel

Integrated GREET/MOVES Generates Results to Put Different Fuels into Perspective



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Thank You!

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