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Modeling Energy and Greenhouse Gas Emissions of CNG and LNG Produced from Landfill Gas

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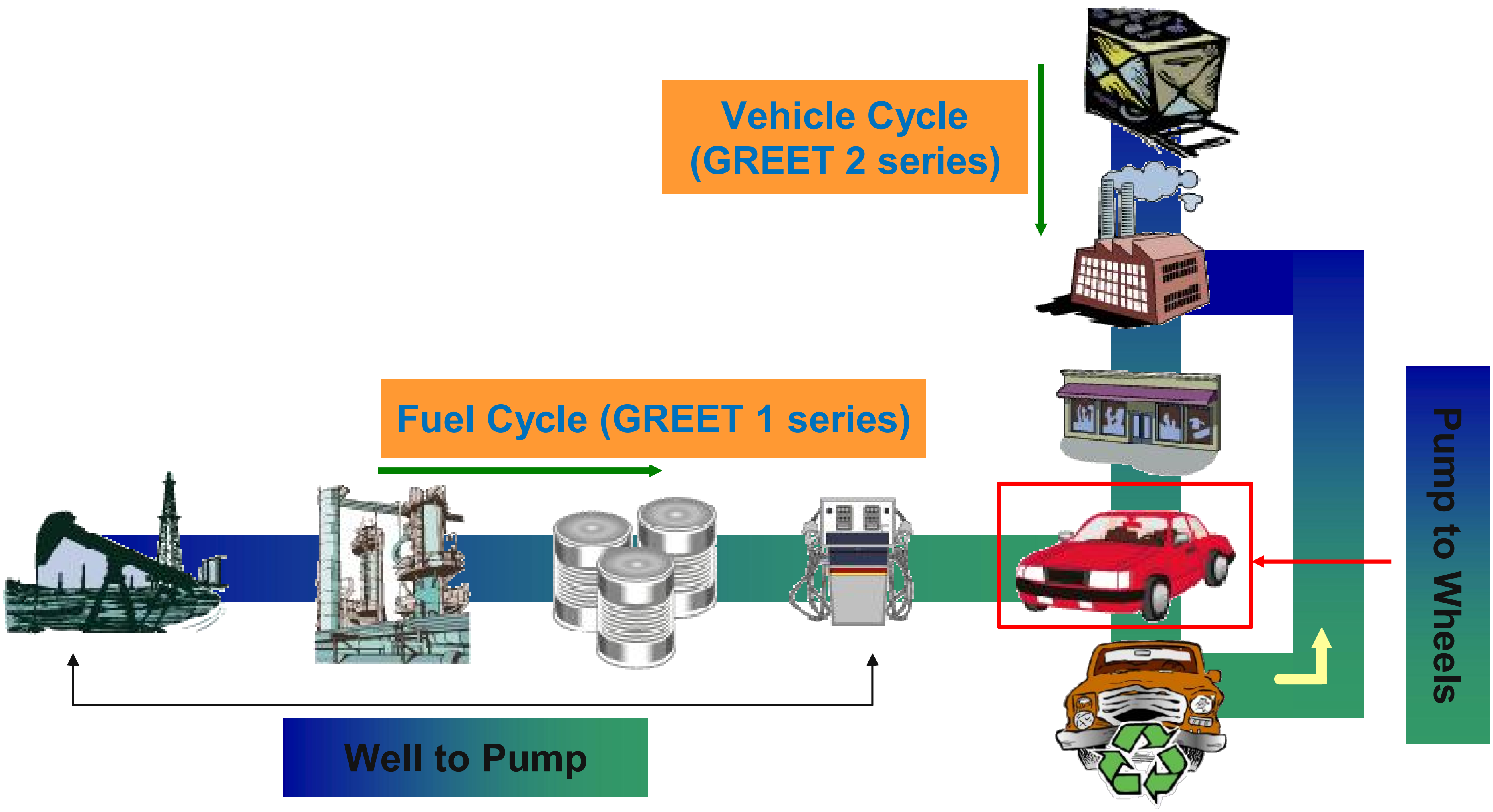
The GREET (Greenhouse gases, Regulated Emissions and Energy use in Transportation) Model

- **Includes emissions of greenhouse gases**
  - CO_2, CH_4, and N_2O
  - VOC, CO, and NO_x as optional GHGs
- **Estimates emissions of five criteria pollutants**
  - Total and urban separately
  - VOC, CO, NO_x, SO_x, and PM_{10}
- **Separates energy use into**
  - All energy sources
  - Fossil fuels (petroleum, natural gas, and coal)
  - Petroleum
- **The GREET1 series and documentation are available at *http://www.transportation.anl.gov/modeling_simulation/GREET/***
  - There are more than 10,000 registered GREET users worldwide
- **The most recent GREET fuel-cycle model (GREET1.8c.0) was released March 23, 2009**

Life-Cycle Analysis for Various Vehicle/Fuel Systems Includes Both Vehicle Cycle and Fuel Cycle



Energy and GHG Emissions Modeling of Landfill Gas (LFG) Is Being Added to the GREET 1 Series

- Define eight generic Well-to-Pump (WTP) pathways

	CNG		LNG	
CO_2 Co-product	Yes	No	Yes	No
Fueling				
Onsite	X	X	X	X
Offsite	X	X	X	X

- Develop inputs to add pathways to GREET model
  - Characterize input and output fuel compositions
  - Collect and validate input, output and process flows (energy, carbon) for process technologies
  - Compute losses, stage and system efficiencies, credits and emissions

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

Petroleum Recovery (97.7%)

↓

Petroleum Transportation and Storage (99%)

↓

Corn

↓

EtOH for Gasoline

↓

Petroleum Refining to Gasoline (84.5-86%, Depending on Oxygenates and Reformulation) and Low-S Diesel (87%)

↓

Transportation, Storage, and Distribution of Gasoline (99.5%)

↓

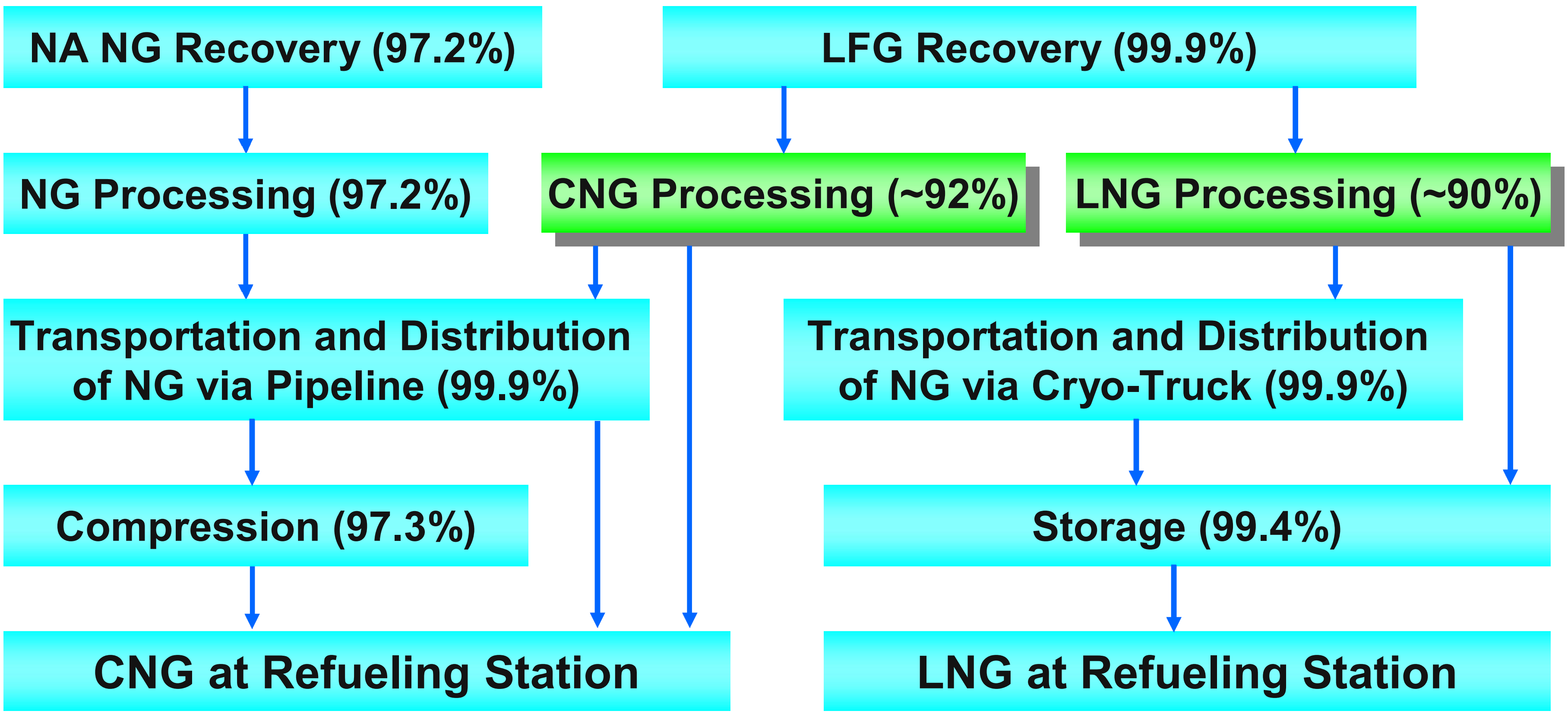
Gasoline and Diesel at Refueling Station

WTP Efficiency (US):
- **Gasoline 80%**
- **Diesel 82%**

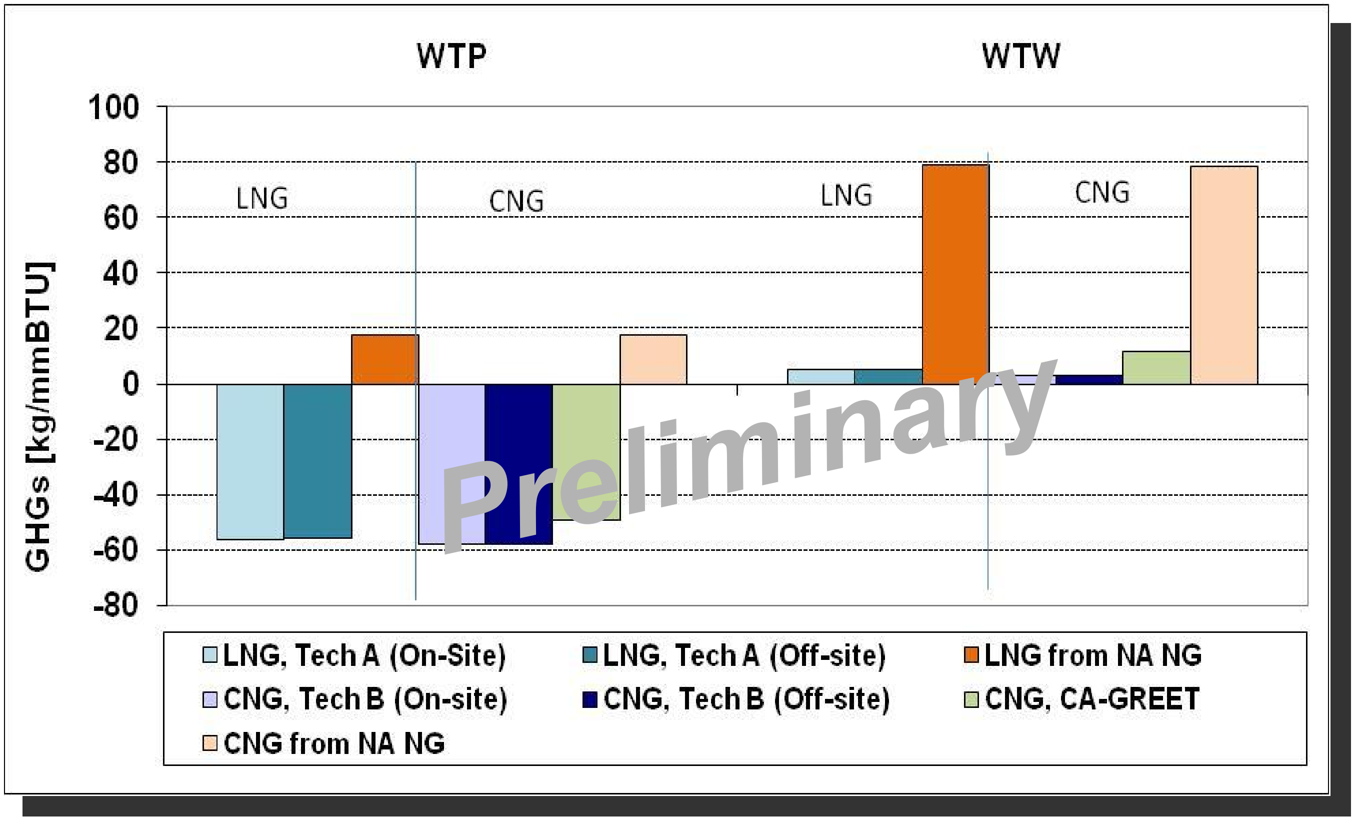
Producing CNG (or LNG) Is the Key Step for LFG-Based Pathways

WTP Efficiency (US):

- **CNG from NA NG 87%**
- **CNG from LFG 78%**
- **LNG from LFG 71%**



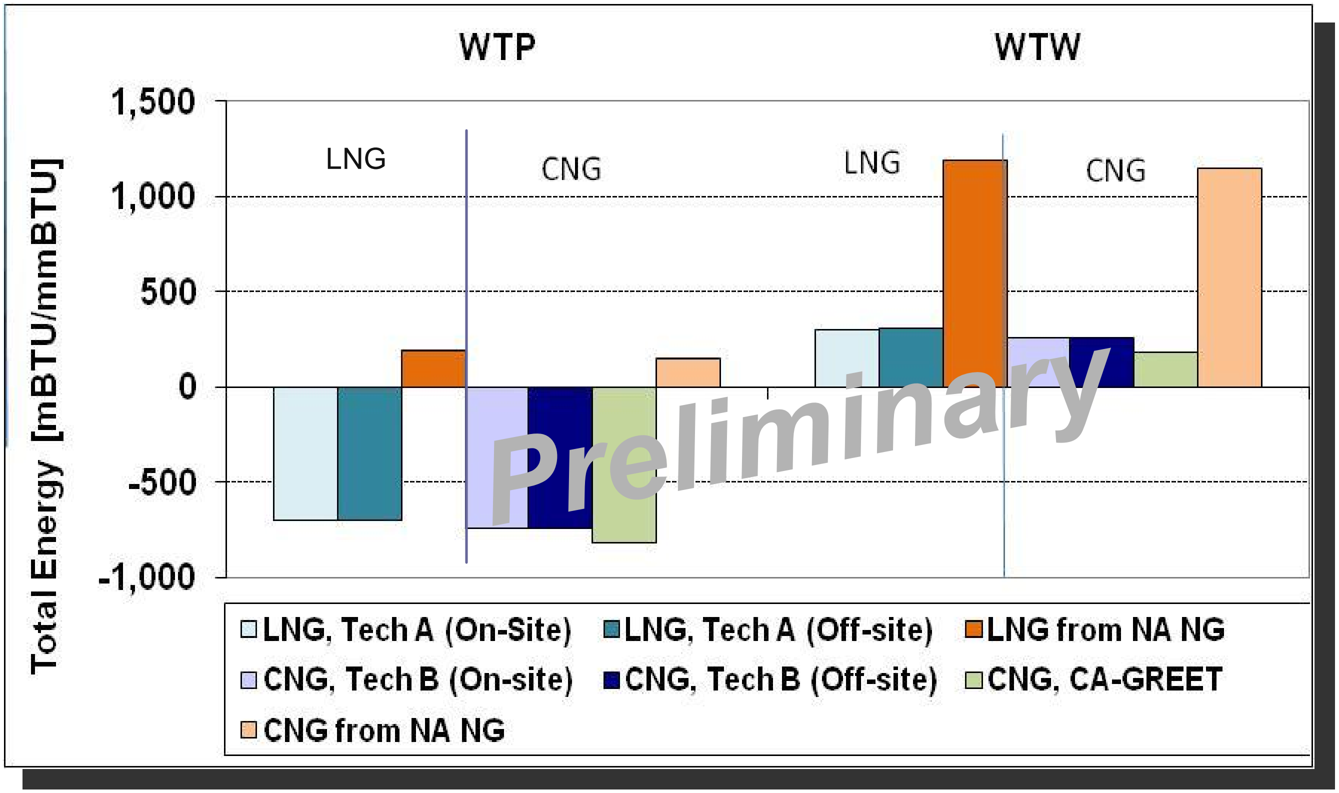
Preliminary Result: ~55kg of GHGs Could Be Avoided (Not Flared) for Each MMBtu of LFG Used



All electricity assumes CA generation mix.

- 1 MMBtu of conventional CNG or LNG accounts for ~20 kg of GHG WTP (~80 kg WTW).
- CNG pathways examined emit less GHG than LNG, and CNG in CA-GREET analysis (which assumes grid electricity produces pipeline quality natural gas).
- Offsite LNG fueling results in slightly more GHG and energy than onsite (due to liquefaction and tank truck distribution).

If LFG Replaced Conventional NG to Fuel CNGVs ~900 MBtu of Energy Could Be Avoided for Each MMBtu of LFG Used



All electricity assumes CA generation mix.

- 1 MMBtu of conventional CNG or LNG consumes ~200,000 Btu WTP (~1.2 million WTW).
- Due to pipeline efficiency, offsite CNG fueling is comparable to onsite.
- ~900 MBtu are avoided (200+700) per MMBtu of LFG used. Use of grid electricity increases energy savings but reduces GHG savings.

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Thank You!!!

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