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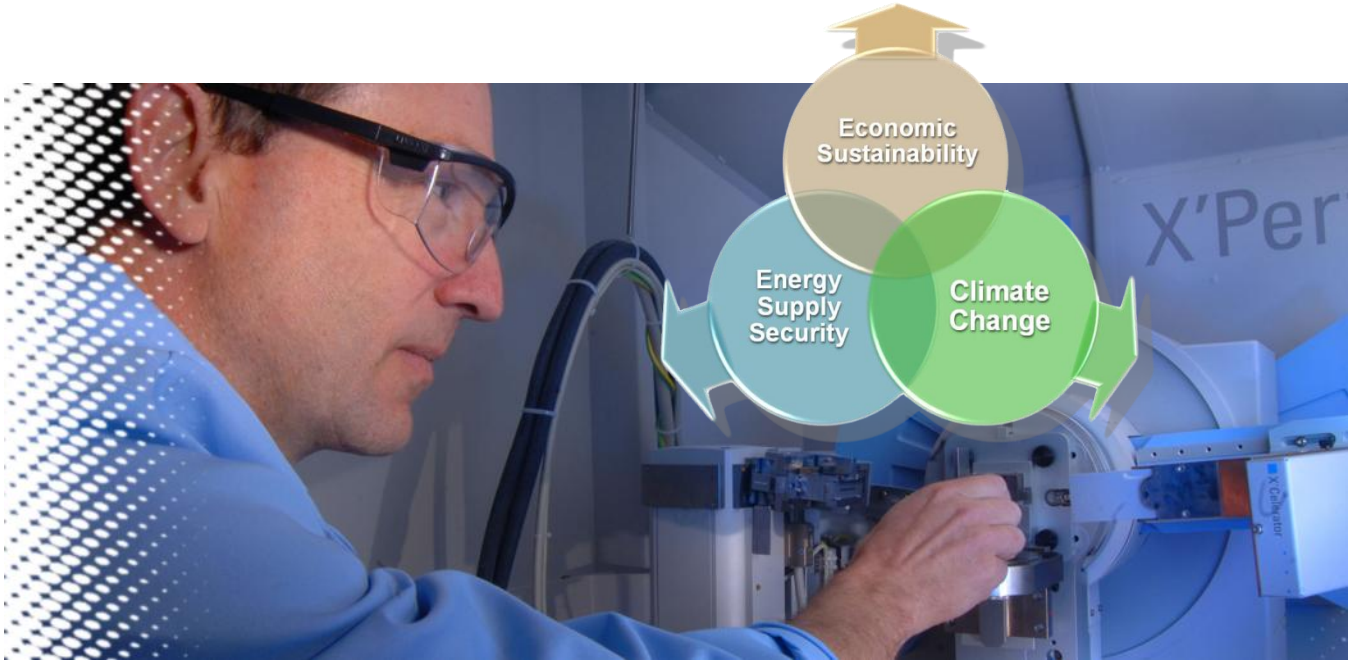

NETL's Capability to Compare Transportation Fuels: GHG Emissions and Energy Security Impacts

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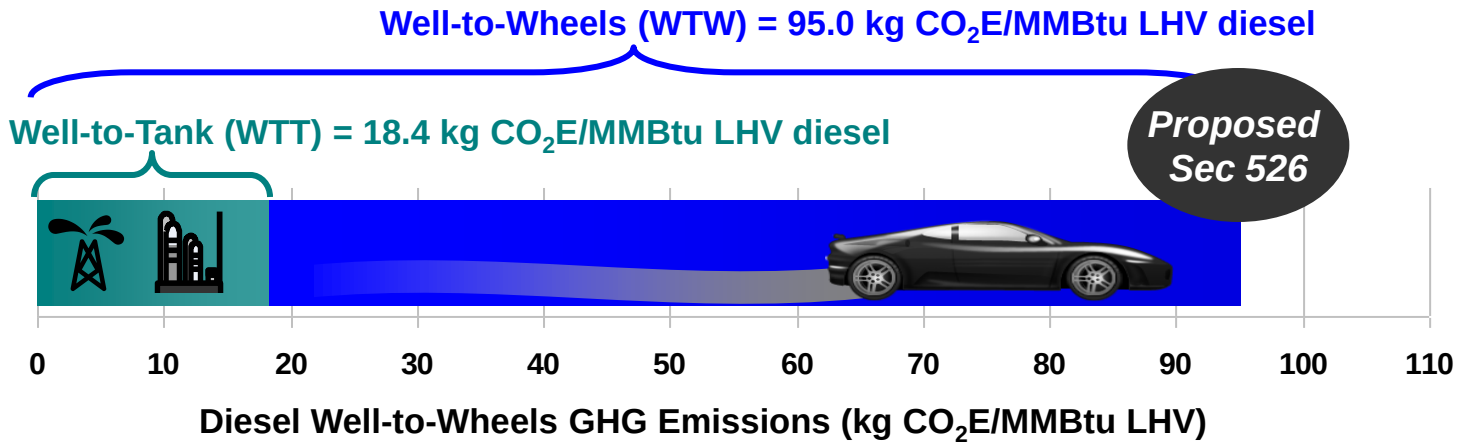
U.S. DEPARTMENT OF ENERGY

Briefing for NETL Director, February 25, 2009; updated April 2, 2009

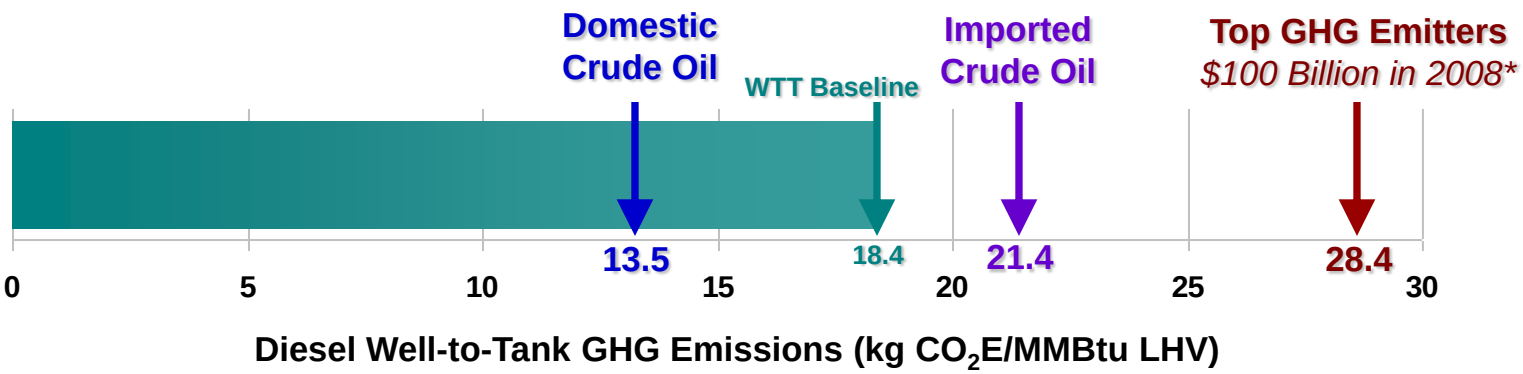
Evaluating GHG Emissions of Transportation Fuels

- **Defined baseline greenhouse gas (GHG) emissions for petroleum-based fuels**



Evaluating GHG Emissions of Transportation Fuels

- **Defined baseline greenhouse gas (GHG) emissions for petroleum-based fuels**
- **Evaluated incremental impacts by crude oil source**

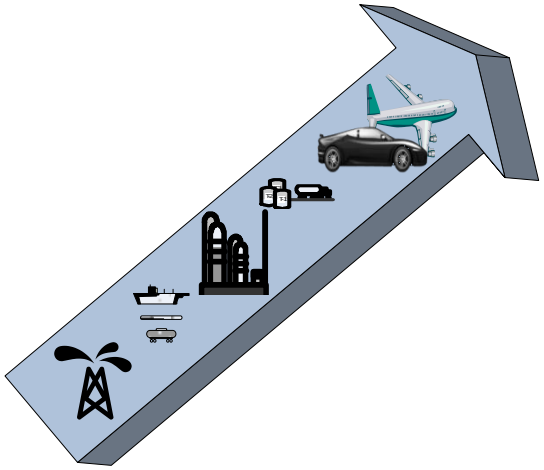


- **Portrayed impact of a PHEV-CO_2-EOR system**

*At a weighted average acquisition price of $92/bbl for Canada oil sands, Venezuela upgraded bitumen, and Mexico and Nigeria crude oil

Presentation Overview

- **Baseline GHG emissions from petroleum-based fuels**



- **GHG emissions for production of diesel by crude oil source**

- **Combining petroleum baseline study with other transportation analyses products**

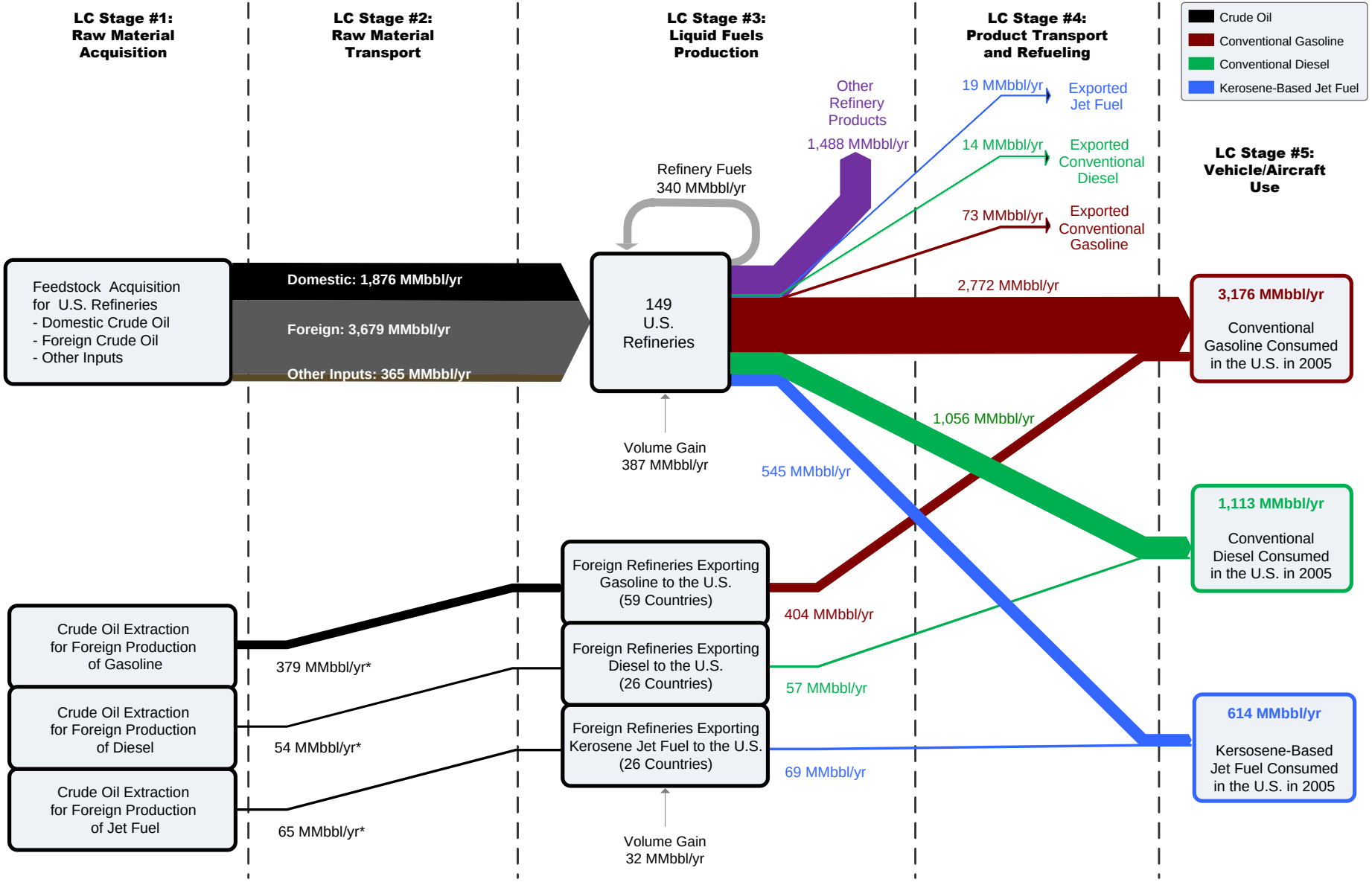
Goal and Application of Petroleum Baseline GHG Emissions Study

Develop life cycle GHG emissions for petroleum-based transportation fuels

Consistent with Energy Independence and Security Act of 2007

To allow accurate comparison of alternative transportation fuel options

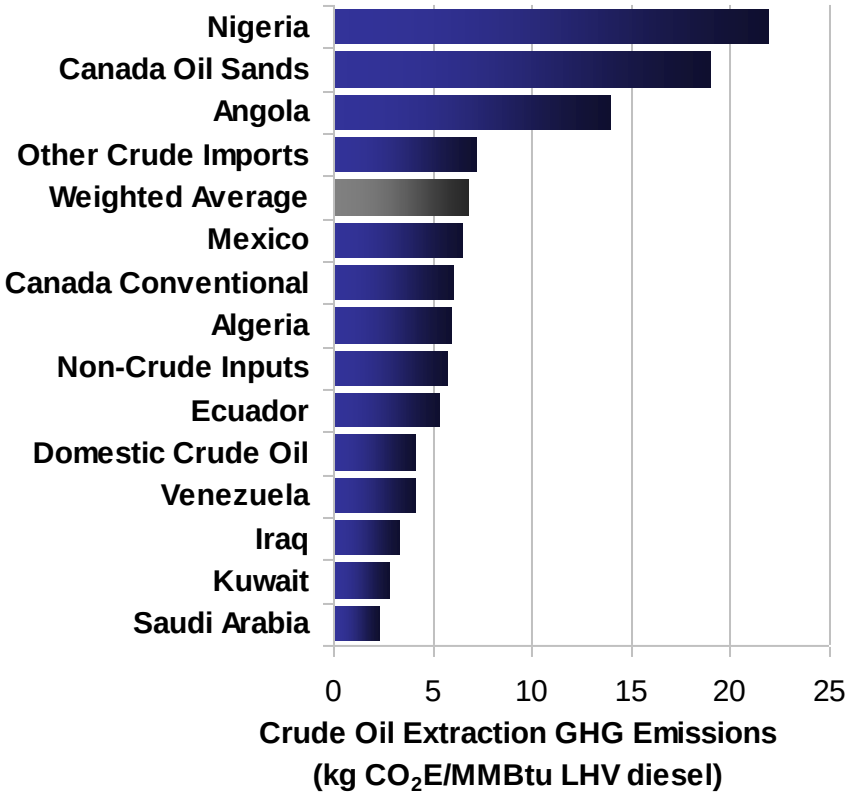
Year 2005 Petroleum Refinery Flows*

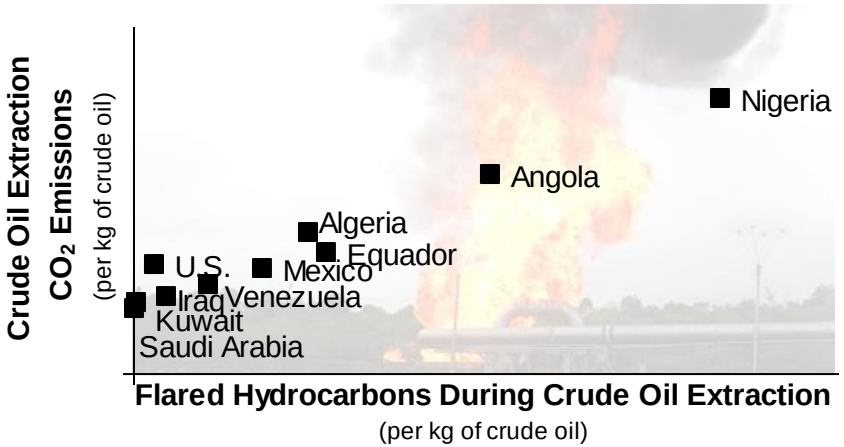


* 2005 U.S. refinery feedstock and product and imported products quantities from Energy Information Administration (EIA) Petroleum Navigator

Crude Oil Extraction Emissions Dependent on Associated Gas Handling and Heavy Oil Production

- **Impact of associated gas flaring and venting**



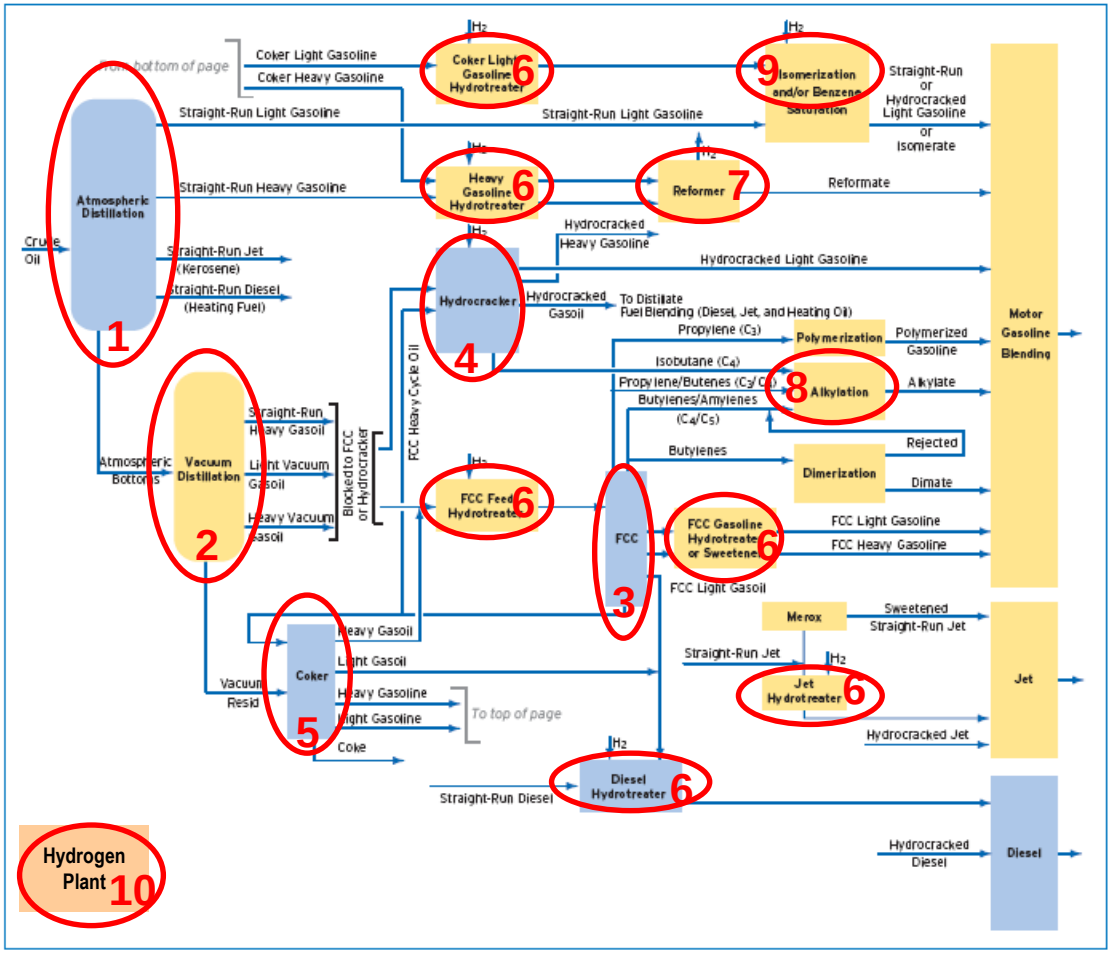


- **Impact of oil sands production**
- **Data limitations in Venezuela**

Assignment of GHG Emissions to Refinery Co-Products is Key

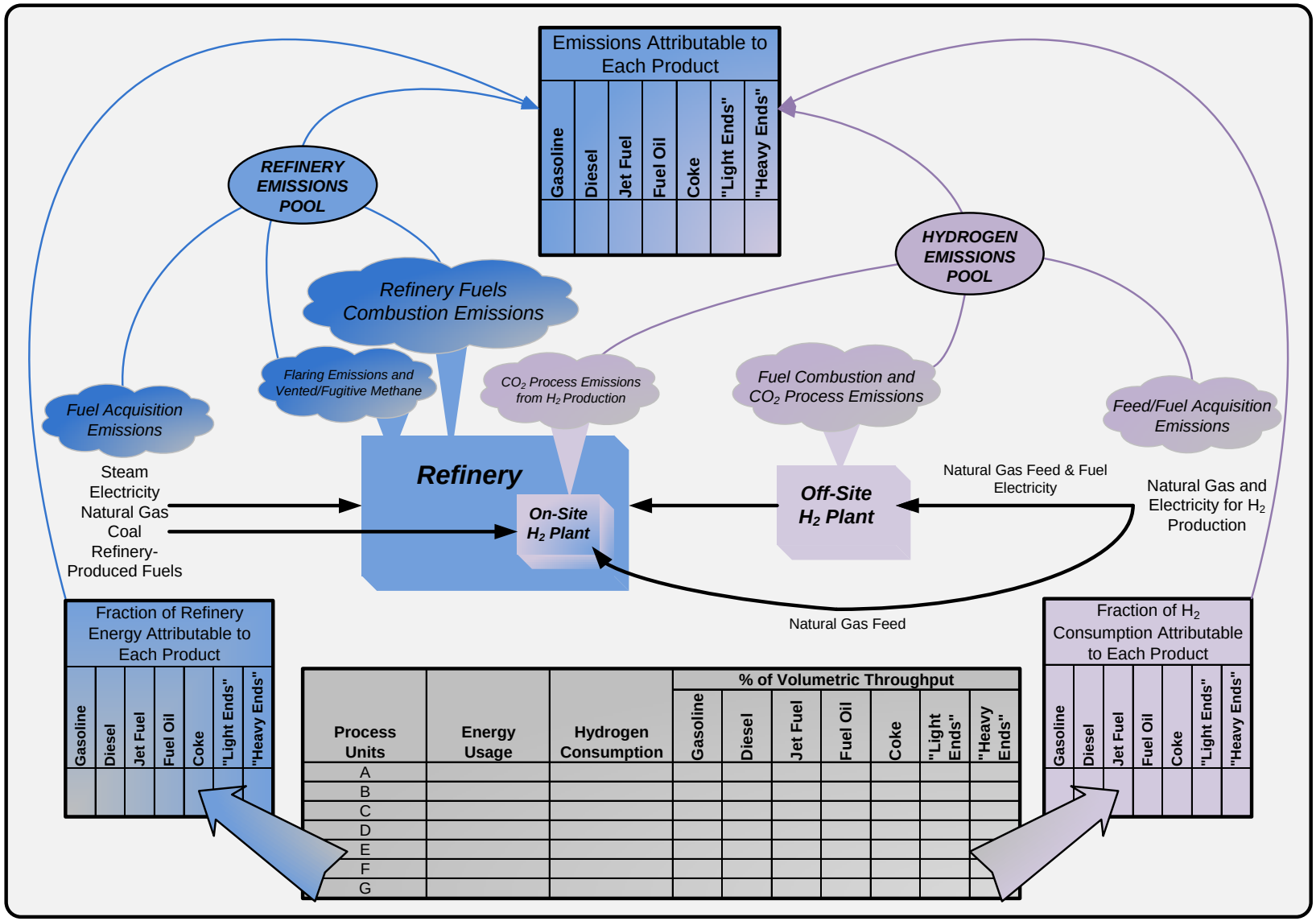
- **EIA data on 2005 fuels consumed at refineries and API emissions factors provide total GHG emissions from refinery operations***

- **Assignment of emissions between refinery co-products using a process-based approach****

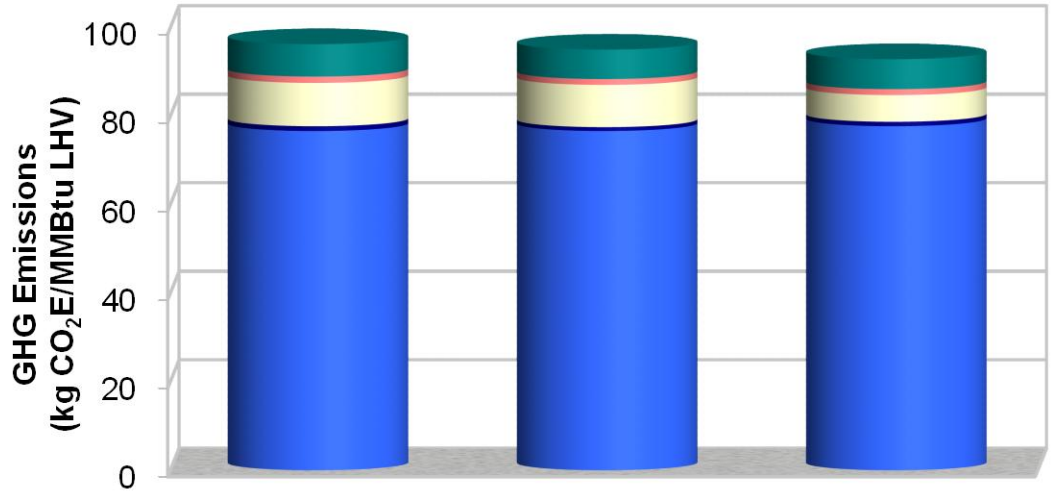


*Additional sources used for GHG emissions estimates for acquisition of hydrogen and purchased fuels/energy
**EIA data provides estimated 2005 throughput of process units and Energetics 2007 study provides process-unit specific energy requirements

Allocation of "Refining" Emissions to Co-Products



Baseline Life Cycle Greenhouse Gas Emissions for Petroleum Transportation Fuels Sold or Distributed in the U.S. in Year 2005

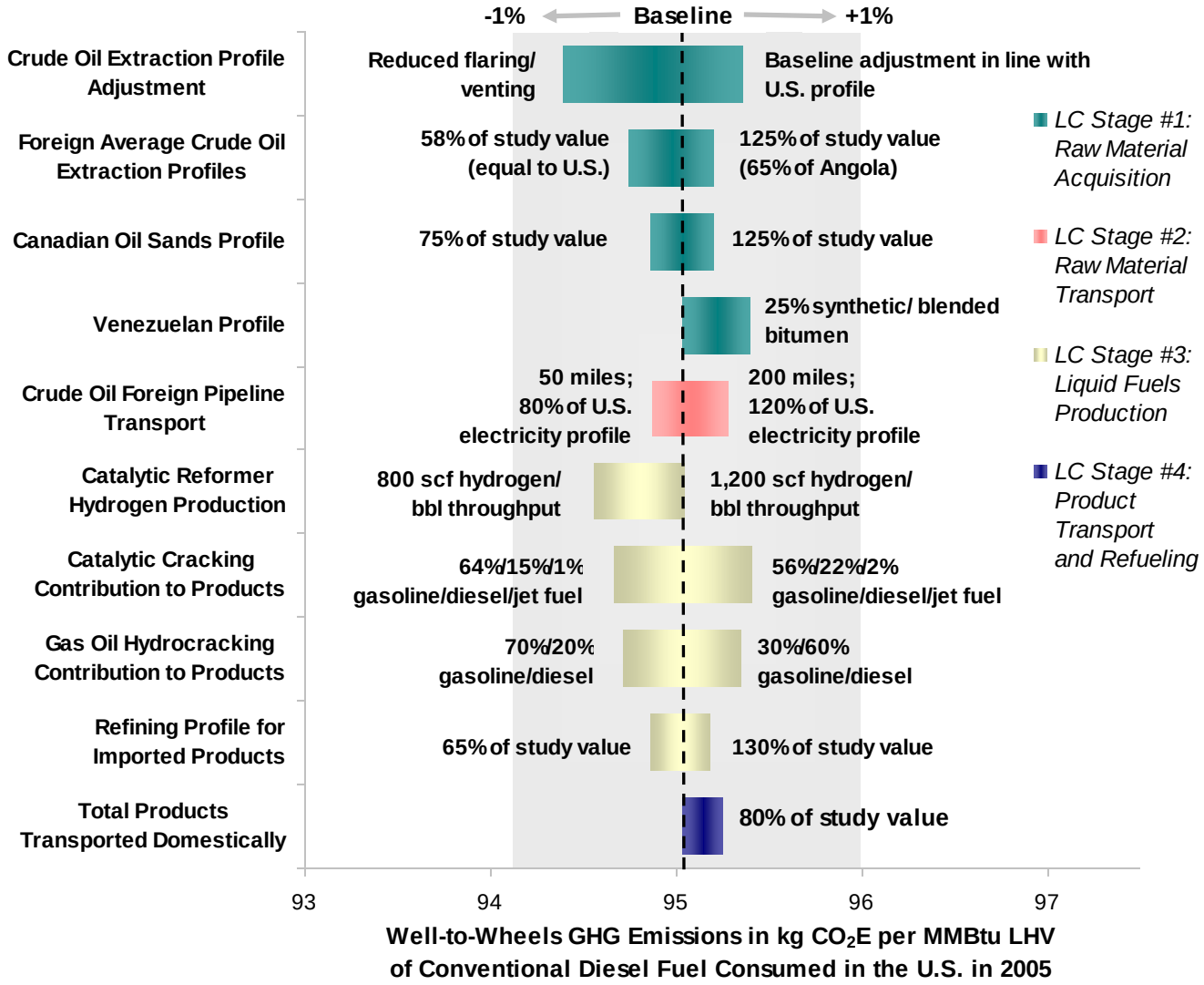


Key	Life Cycle Stage	Conventional Gasoline		Conventional Diesel		Kerosene-Based Jet Fuel	
	Crude Oil Extraction	7.3	8%	6.6	7%	6.8	7%
	Crude Oil Transport	1.4	1%	1.3	1%	1.3	1%
	Refinery Operations	9.8	10%	9.5	10%	6.0	6%
	Finished Fuels Transport	1.1	1%	0.9	1%	1.0	1%
	Combustion of Fuel	76.6	80%	76.7	81%	77.7	84%
	Total: Well-to-Tank (WTT)	19.6	20%	18.4	19%	15.1	16%
	Total: Well-to-Wheels (WTW)	96.3	100%	95.0	100%	92.9	100%

Well-to-Tank

Well-to-Wheels

Sensitivity Analysis on Diesel Well-to-Tank Baseline GHG Emissions



- **30 parameters evaluated**
- **Each parameter evaluated**
  - <4% shift in WTT profile
  - <1% shift in WTW profile

Goal and Drivers of Crude Oil Source-Specific GHG Emissions Analysis

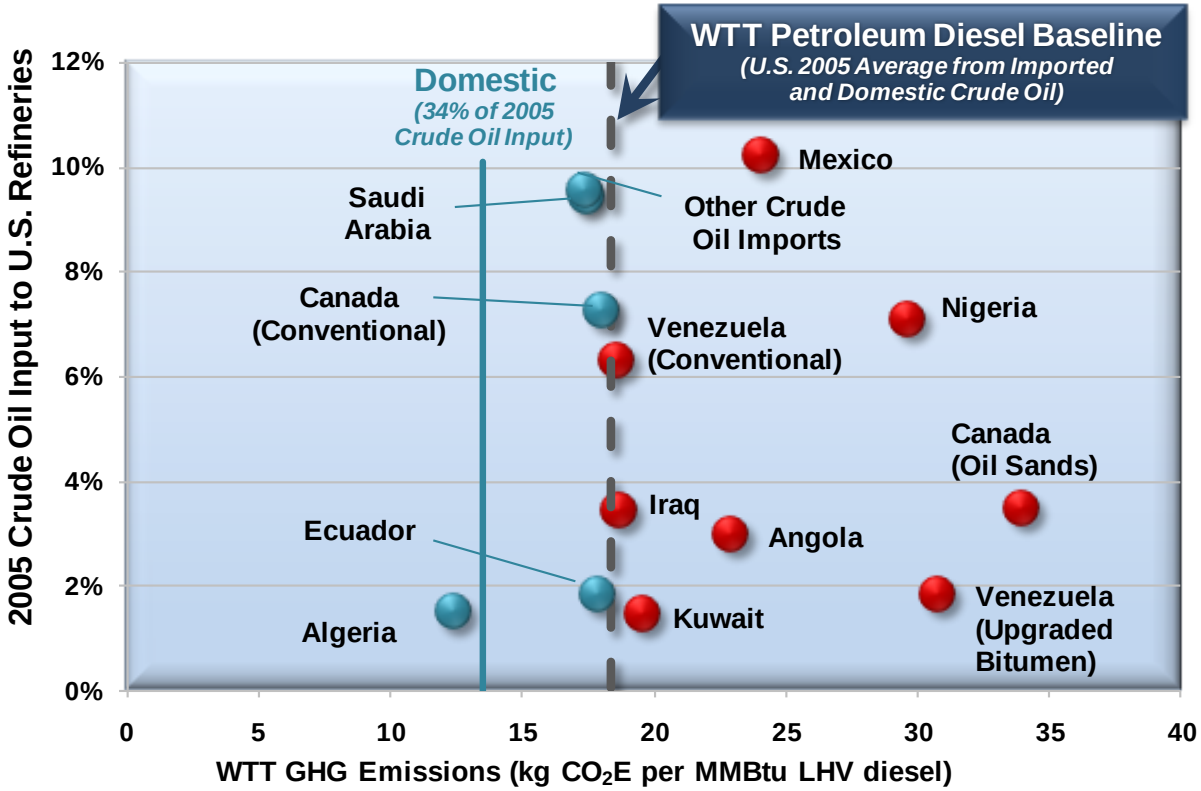
Understand variability of GHG emissions by crude oil source

Consistent with 2005 petroleum baseline GHG emissions analysis

To enhance comparison of alternative transportation fuel options

GHG Emissions for Production of Diesel Fuel Variability by Imported Feedstock Source

WTT GHG emissions for diesel production from imported crude oil sources vary from -35% to +80% of 2005 baseline



WTT GHG emissions ~20% of the baseline WTW profile; remaining 80% due to combustion of the fuel

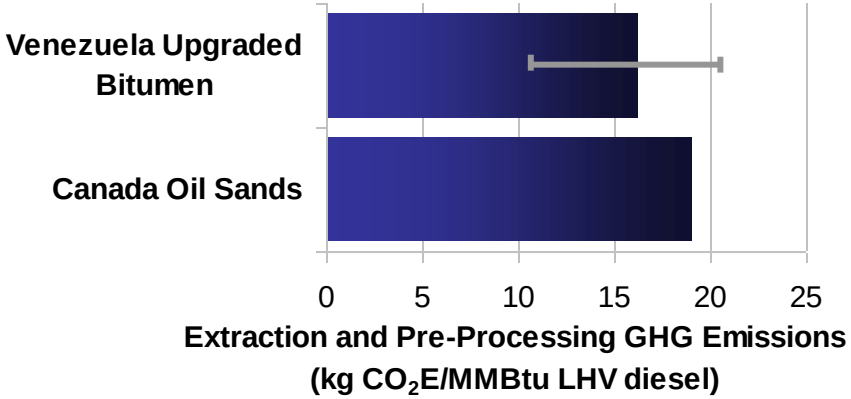
Drivers of Variability in Source-Specific GHG Emissions by Feedstock Source

- Flaring and venting of associated natural gas during extraction
- Alternative extraction techniques and pre-processing requirements required for oil sands and bitumen
- Ocean transport distances
- Varying processing requirements within the refinery for crude oils of different quality

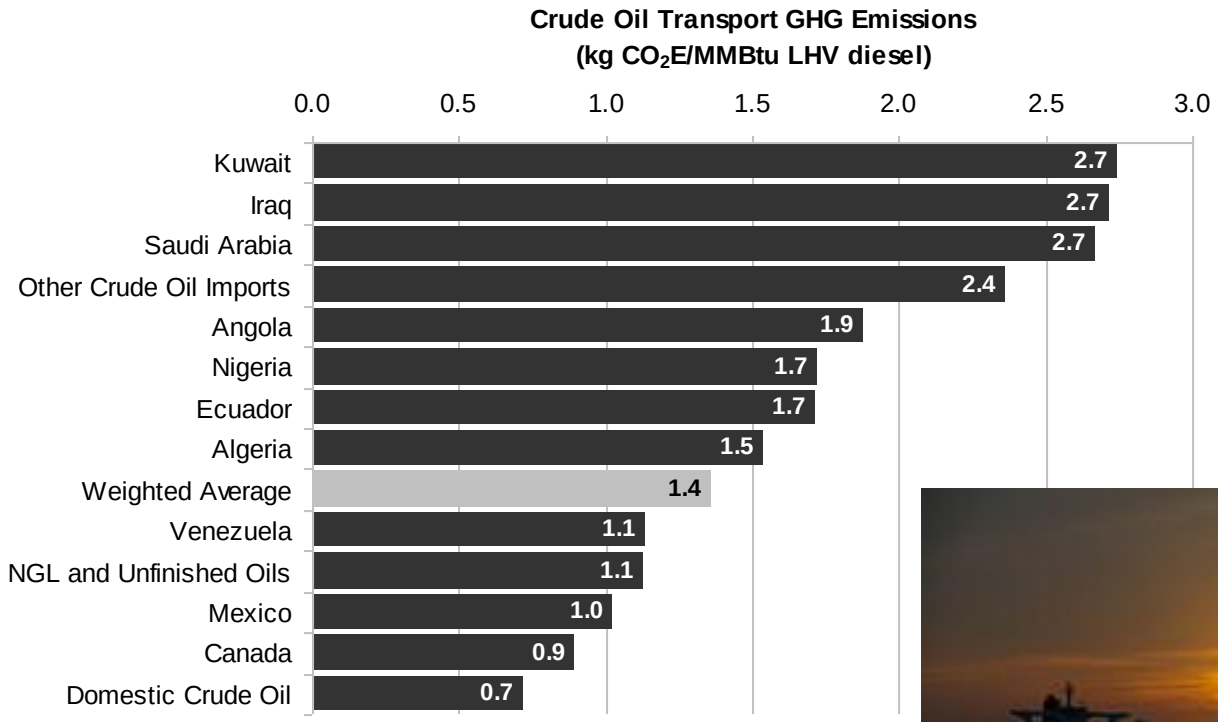
Challenges in Evaluating GHG Emissions for Venezuelan Bitumen Acquisition

- **Raw material extraction and transport GHG emissions profiles available from baseline analysis by import source**

- **Evaluating Venezuela bitumen acquisition profile**
  - Canada oil sands v Venezuela bitumen
  - 90% confidence interval developed due to limited availability of data



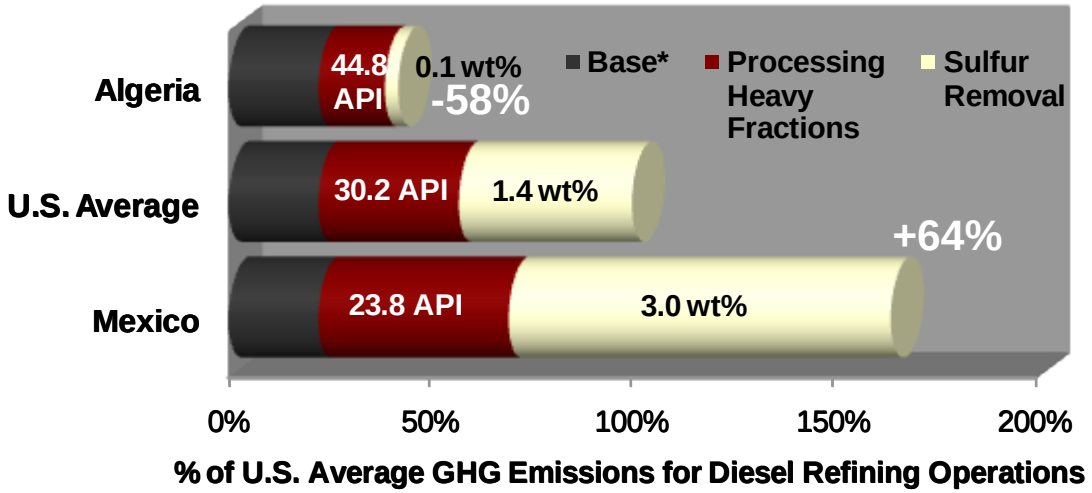
Raw Material Transport Impacts Variability to a Lesser Degree



Persian Gulf crude oil transport GHG emissions double

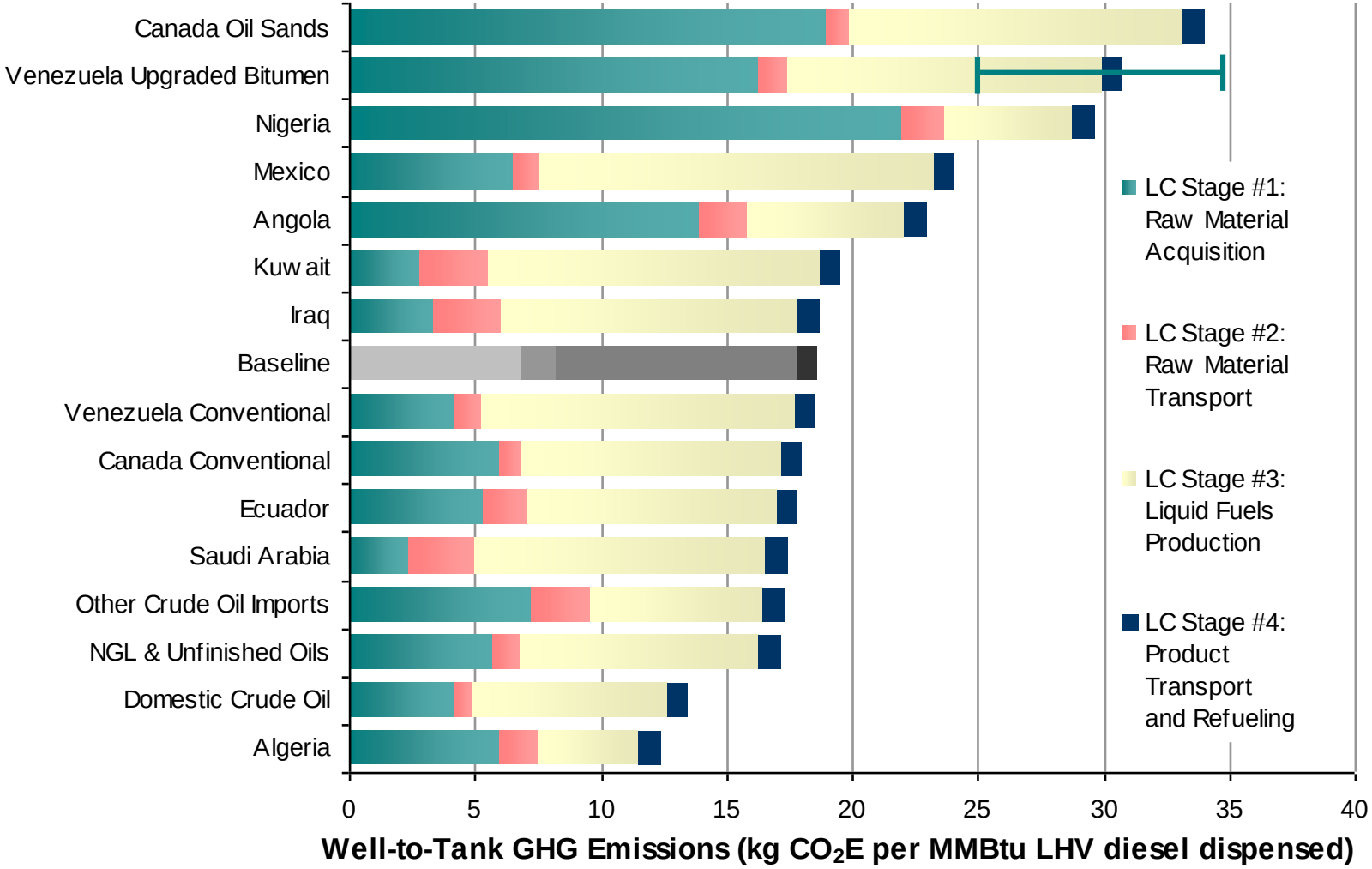
Refinery Processing Requirements Impacted by Crude Oil Quality

- **Crude oil quality impacts refining requirements**
  - NOT a process model to evaluate refining 100% of a given crude oil
  - Heuristics developed to determine impact of API gravity and sulfur content
  - Baseline analysis provides emissions associated with refining operations impacted by crude quality

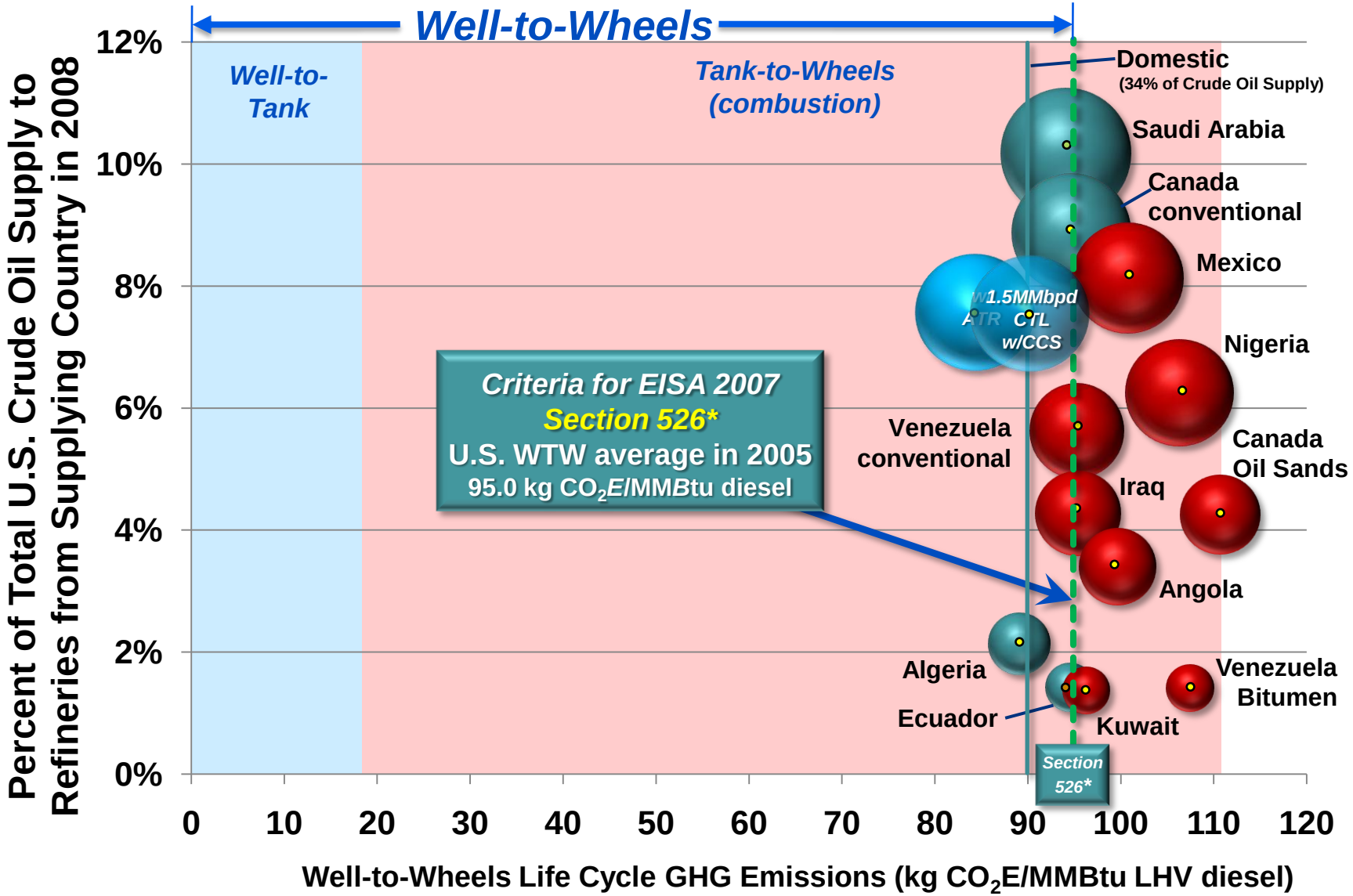


*Base GHG emissions are those not due to processing heavy fractions or sulfur removal and thus are not significantly impacted by API gravity or sulfur content

Source-Specific Diesel Fuel Life Cycle GHG Emissions by Life Cycle Stage



CTL w/CCS: A Well-to-Wheels GHG Emissions Advantage



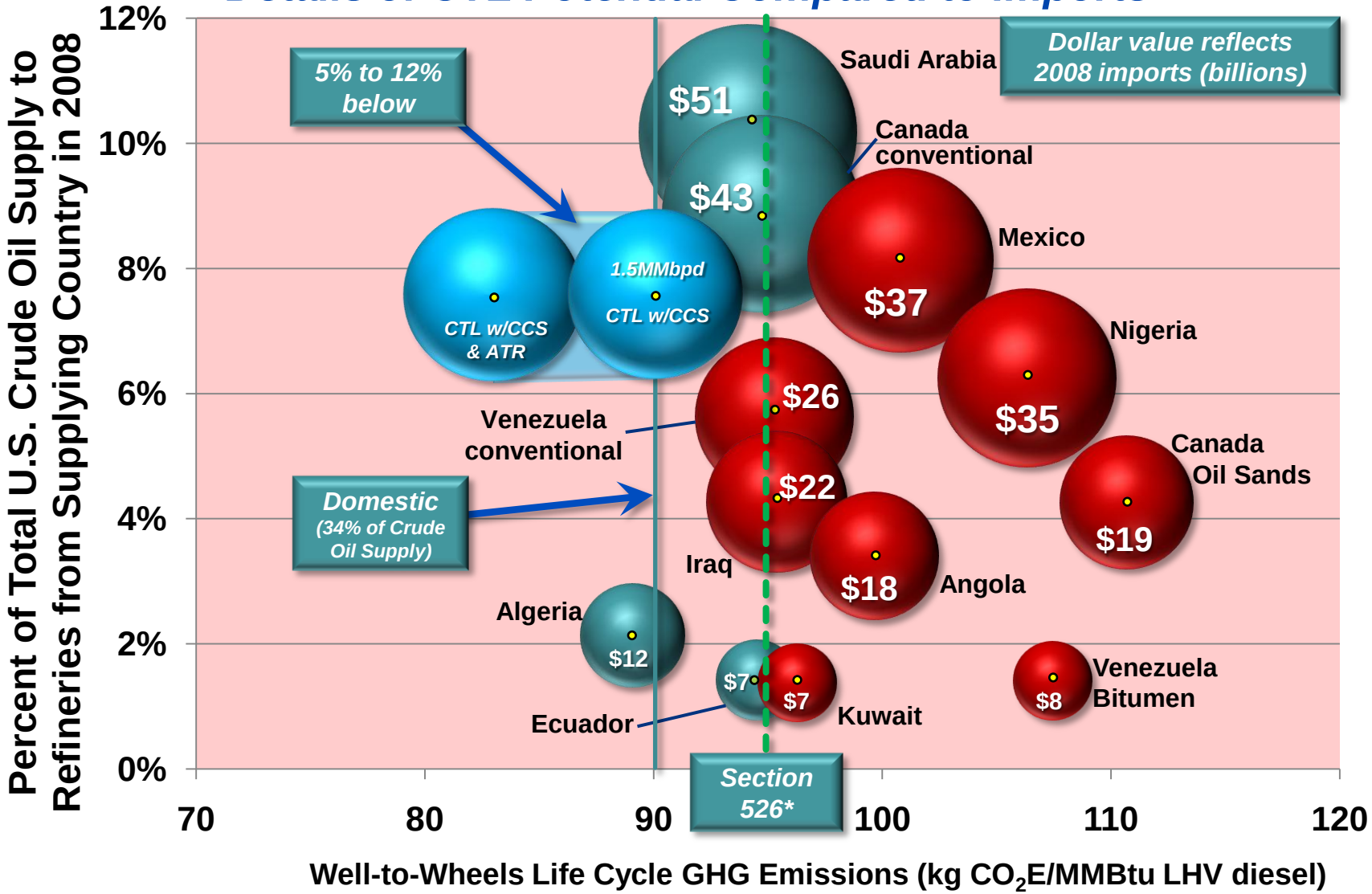
*52% of Imports** to U.S. in 2008 Above the 2005 WTW GHG Baseline (Sec. 526)*

** Source: NETL report, Development of Baseline Data and Analysis of Life Cycle Greenhouse Gas Emissions of Petroleum-Based Fuels, November 26, 2008*

NETL Petroleum Baseline "Section 526" value is a proxy pending designation by the EPA administrator according to EISA 2007

A Well-to-Wheels GHG Emissions Advantage

Details of CTL Potential Compared to Imports

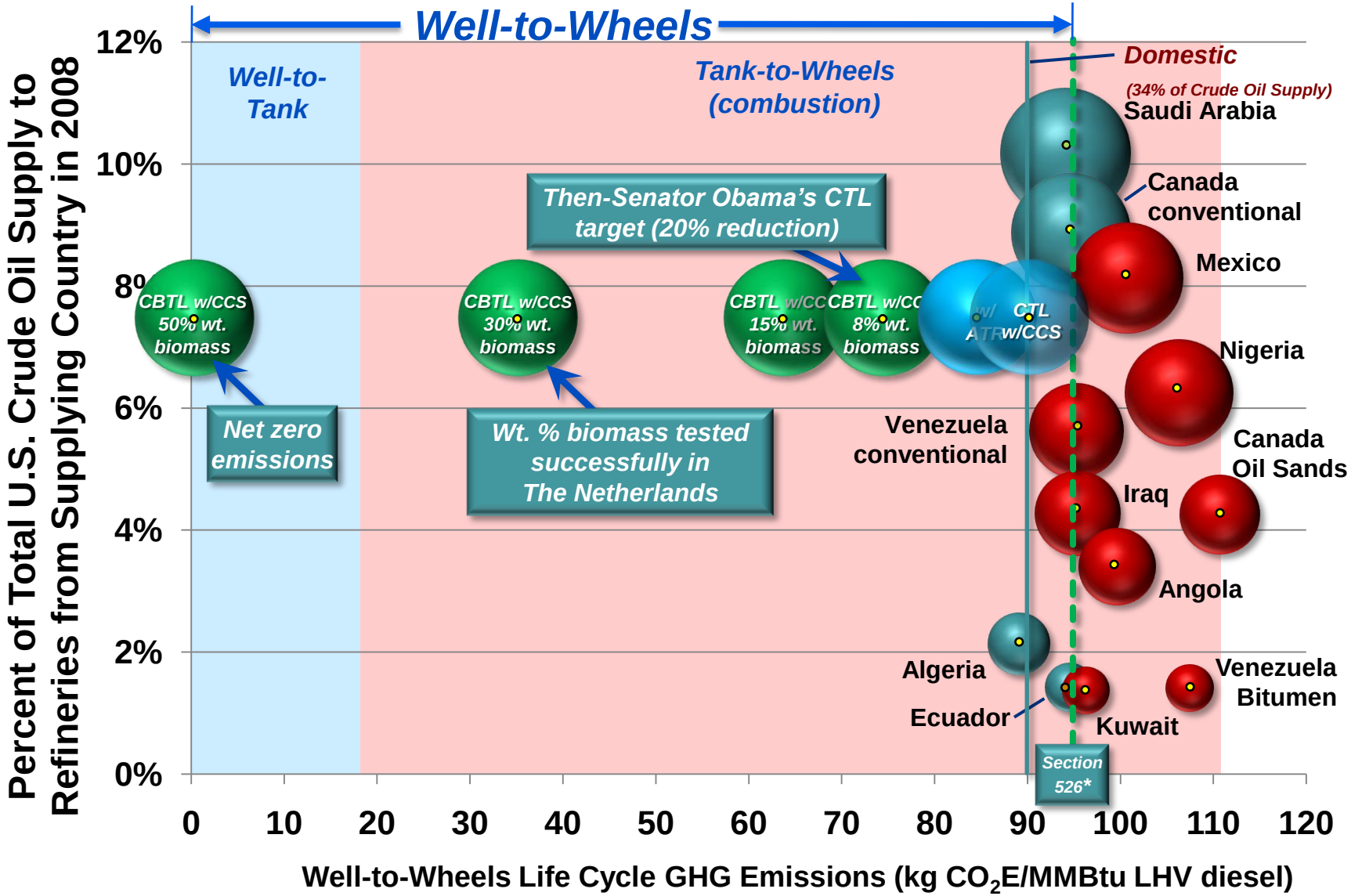


$172 billion of 2008 imports would not meet Section 526 Life-cycle requirement

* *Source: NETL report, Development of Baseline Data and Analysis of Life Cycle Greenhouse Gas Emissions of Petroleum-Based Fuels, November 26, 2008*

NETL Petroleum Baseline "Section 526" value is a proxy pending designation by the EPA Administrator according to EISA 2007

CBTL w/CCS: A Well-to-Wheels GHG Emissions Advantage



52% of Imports to U.S. in 2008 Above the 2005 WTW GHG Baseline (Sec. 526)**

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NETL Petroleum Baseline "Section 526" value is a proxy pending designation by the EPA administrator according to EISA 2007

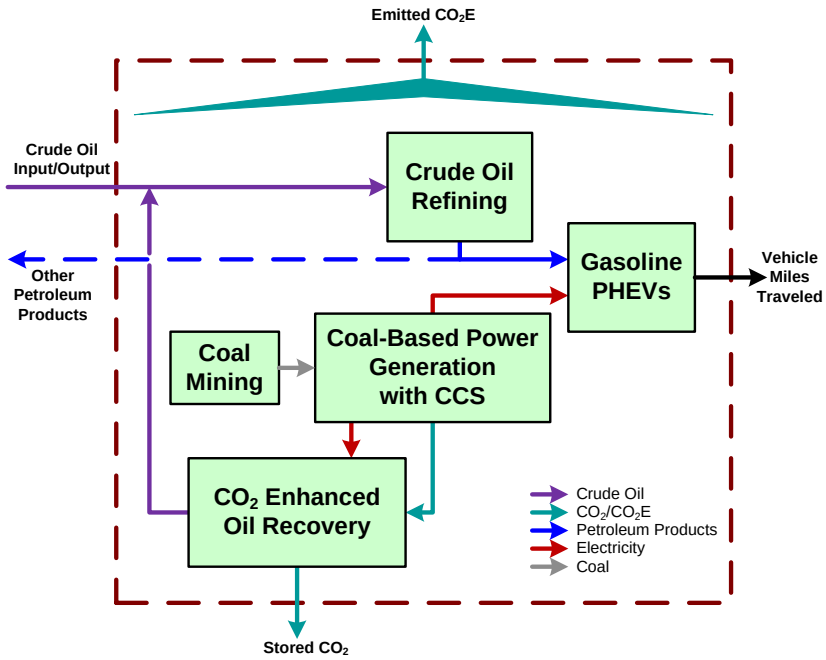
Comparison Considerations

- **Representative GHG emissions profile – 2005 U.S. Average**
  - Efficiency improvements
  - Operational changes
  - Crude oil quality shifts

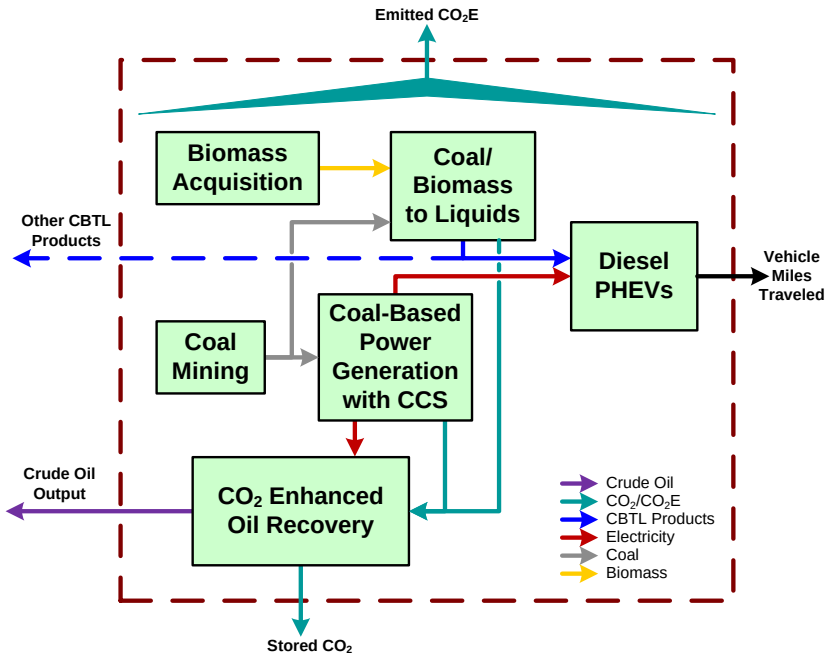
- **Drivers of marginal crude oil source**
  - Economics
  - Energy security
  - GHG emissions

Expanding Domestic Benefits with PHEV and CO_2-EOR

PHEV fueled by petroleum-based GASOLINE and IGCC power where captured CO_2 is used for CO_2-EOR

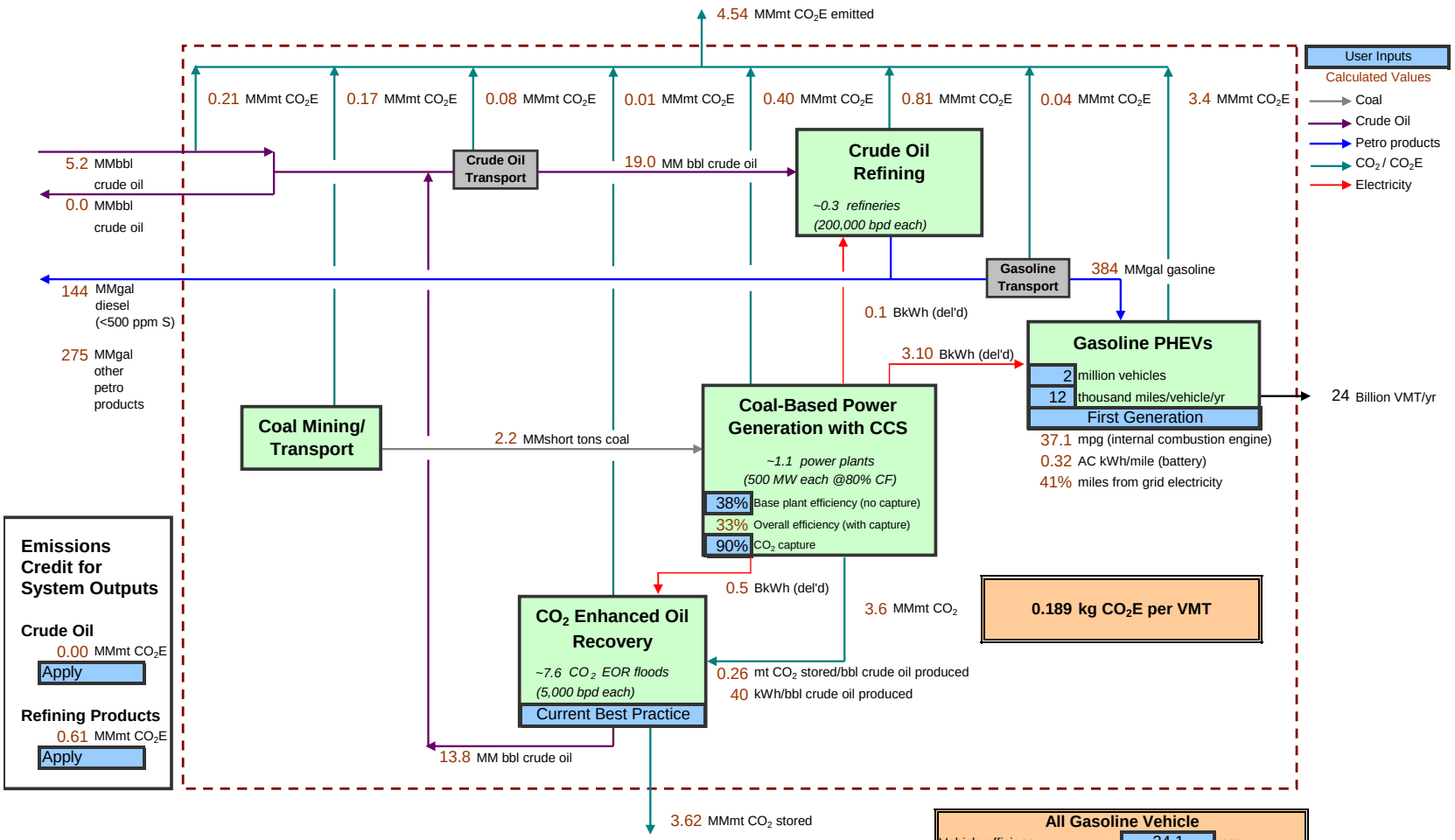


PHEV fueled by CTL DIESEL and IGCC power where captured CO_2 is used for CO_2-EOR



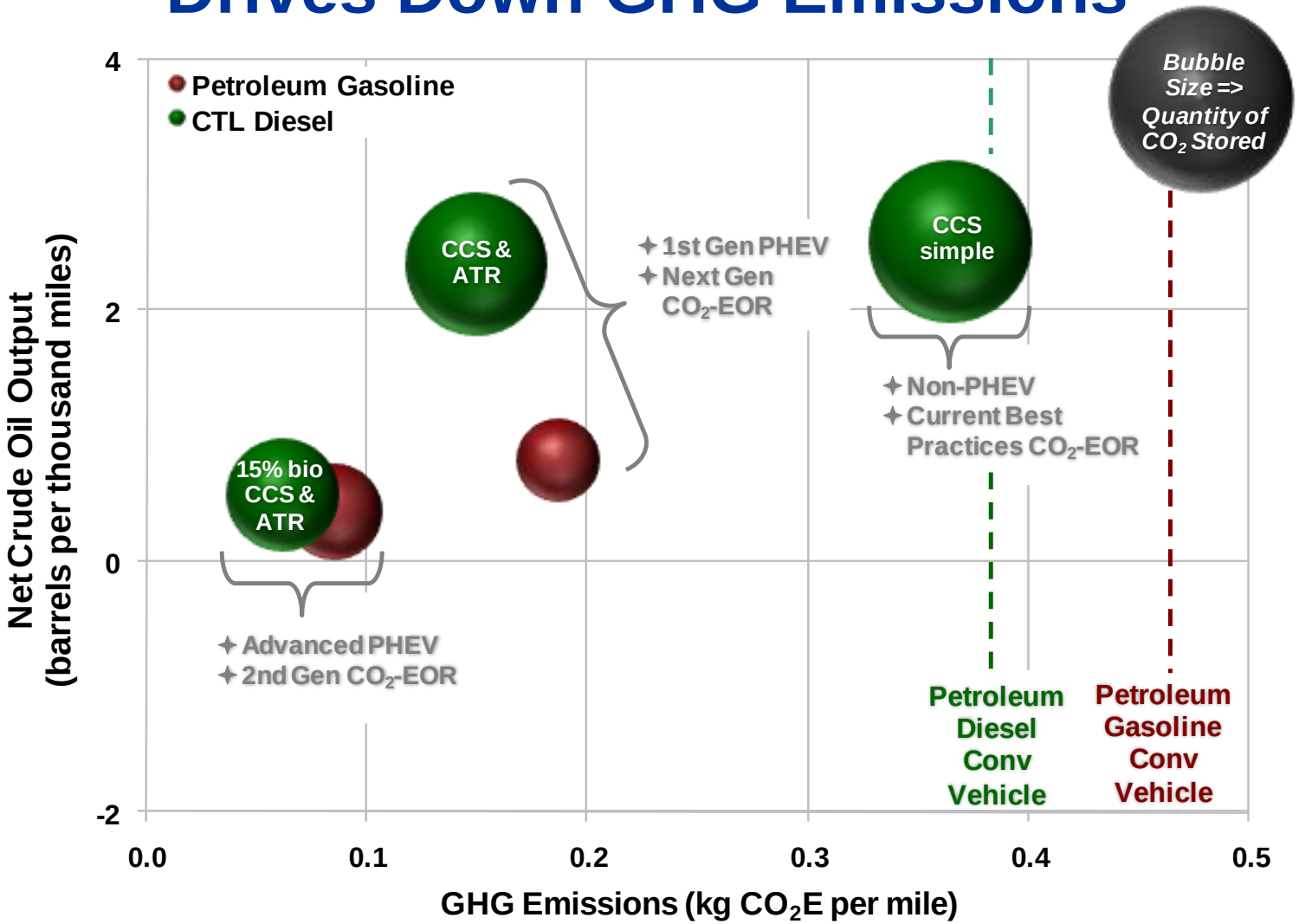
Snapshot of Tool – Petroleum Gasoline

Material flows in a gasoline PHEV system where captured CO_2 from power is used for CO_2 EOR



All Gasoline Vehicle		
Vehicle efficiency	24.1	mpg
Point of combustion	0.370	kg CO_2E/mile
E&P, refining, transport	0.096	kg CO_2E/mile
Total	**0.466**	kg CO_2E/mile

Advancement of Multiple Technologies Drives Down GHG Emissions

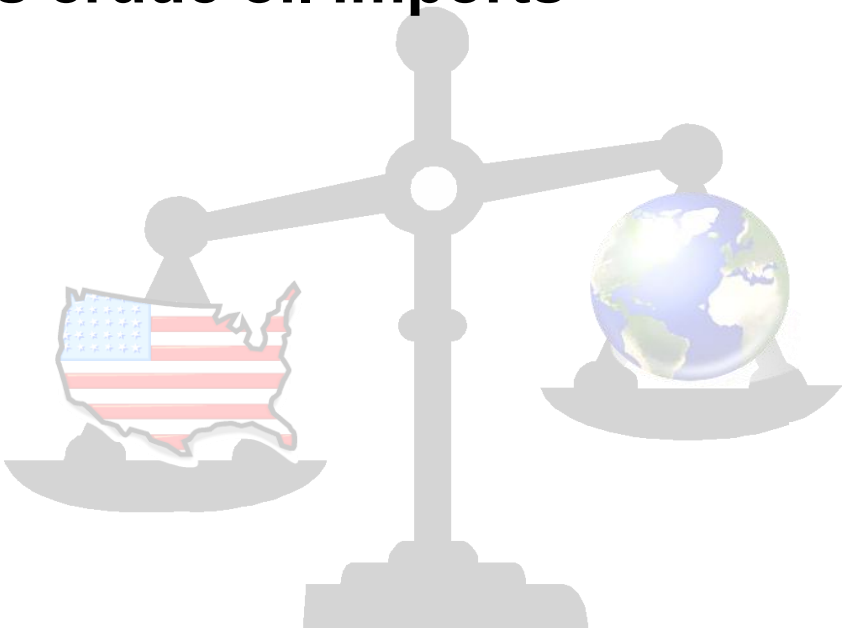


Conclusions

- **Defined baseline greenhouse gas (GHG) emissions for petroleum-based fuels**

- **Showed the GHG emission and economic advantage of domestic crude oil and CTL with CCS for production of diesel versus crude oil imports**

- **Portrayed impact of a PHEV-CO2-EOR system**



Status

- **Presentation:** http://www.netl.doe.gov/energy-analyses/pubs/Petroleum%20Fuels%20GHG%20Modeling_Feb%2025a.pdf
- **Summary Document:** http://www.netl.doe.gov/energy-analyses/pubs/Life%20Cycle%20GHG%20Analysis%20of%20Diesel%20Fuel%20by%20Crude%20Oil%20Source%202.pdf
- **Petroleum Baseline GHG Emissions Report**
  - Published to NETL website Nov 2008
    http://www.netl.doe.gov/energy-analyses/pubs/NETL%20LCA%20Petroleum-Based%20Fuels%20Nov%202008.pdf
  - Submitted to EPA for consideration for EISA 2007
- **Crude Oil Source-Specific Report**
  - Published to NETL website Mar 2009
    http://www.netl.doe.gov/energy-analyses/pubs/PetrRefGHGEmiss_ImportSourceSpecific1.pdf
- **PHEV-CO_2EOR-CBTL GHG Emissions Tool**
  - Posted on NETL website Jan 2009
    http://www.netl.doe.gov/energy-analyses/pubs/PHEV-CO2EOR-CCS_12-16_CBTL.xls