# PRELIM - Petroleum REfinery Life Cycle Inventory Model


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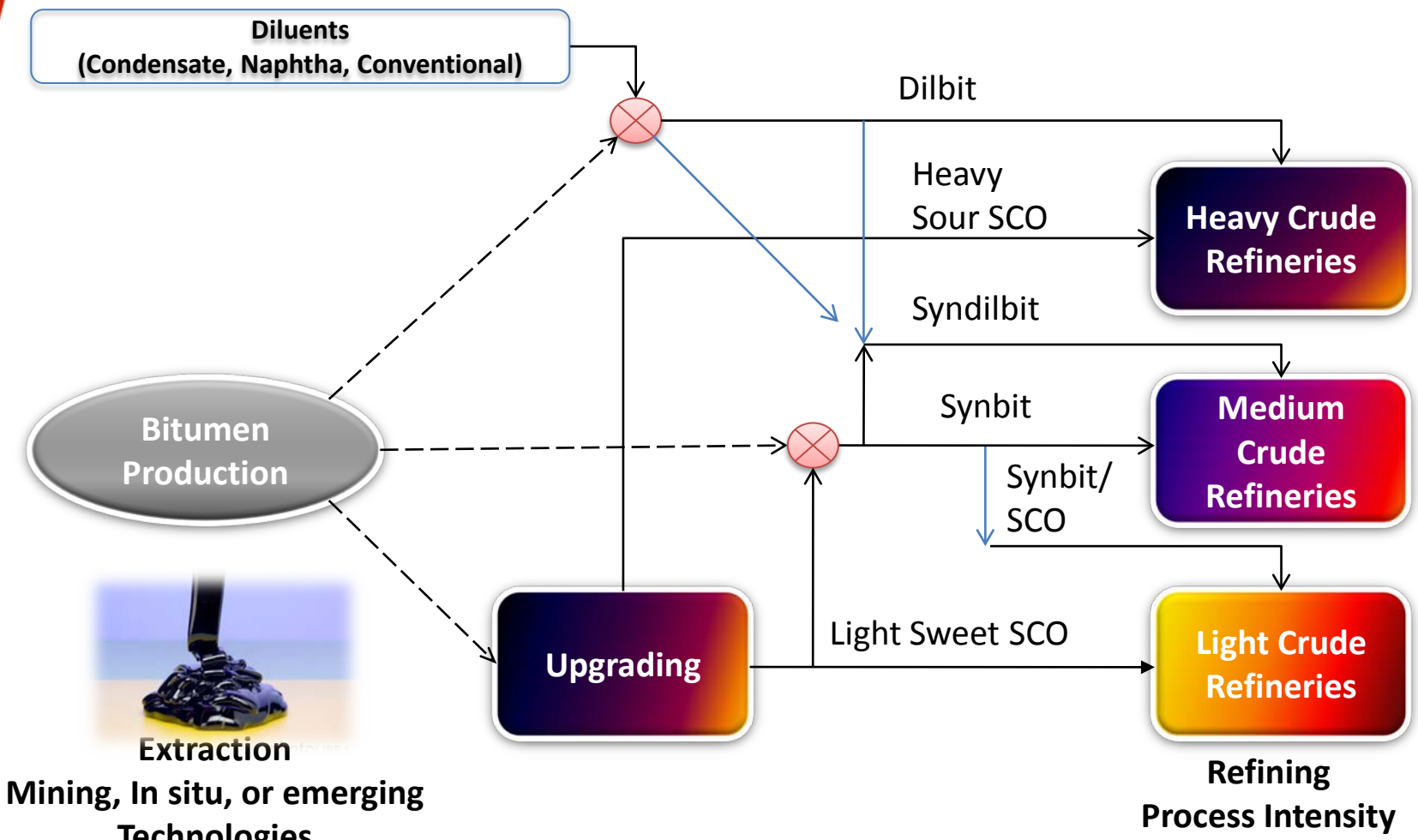
## Motivation

- Diversity of crude quality and refinery configurations
- Current life cycle-based GHG models to inform policy lack model detail to capture this variability

## Objective

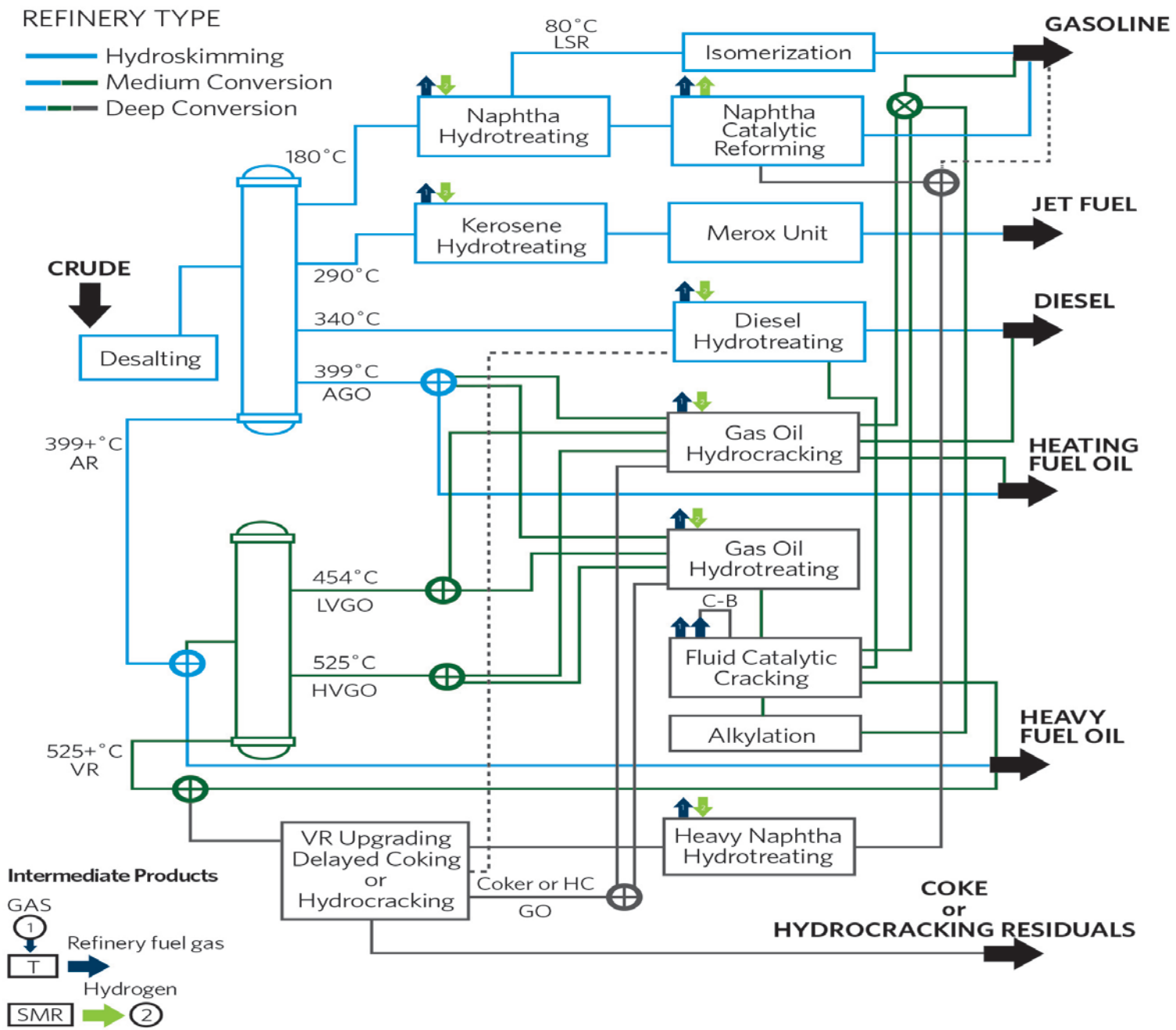
- More detailed investigation of the impacts of crude quality and refinery configuration on energy use and GHG emissions at refineries

# Motivation – Variation in oil sands products




Source: Adapted from Gary R. Brierley et al, 2006

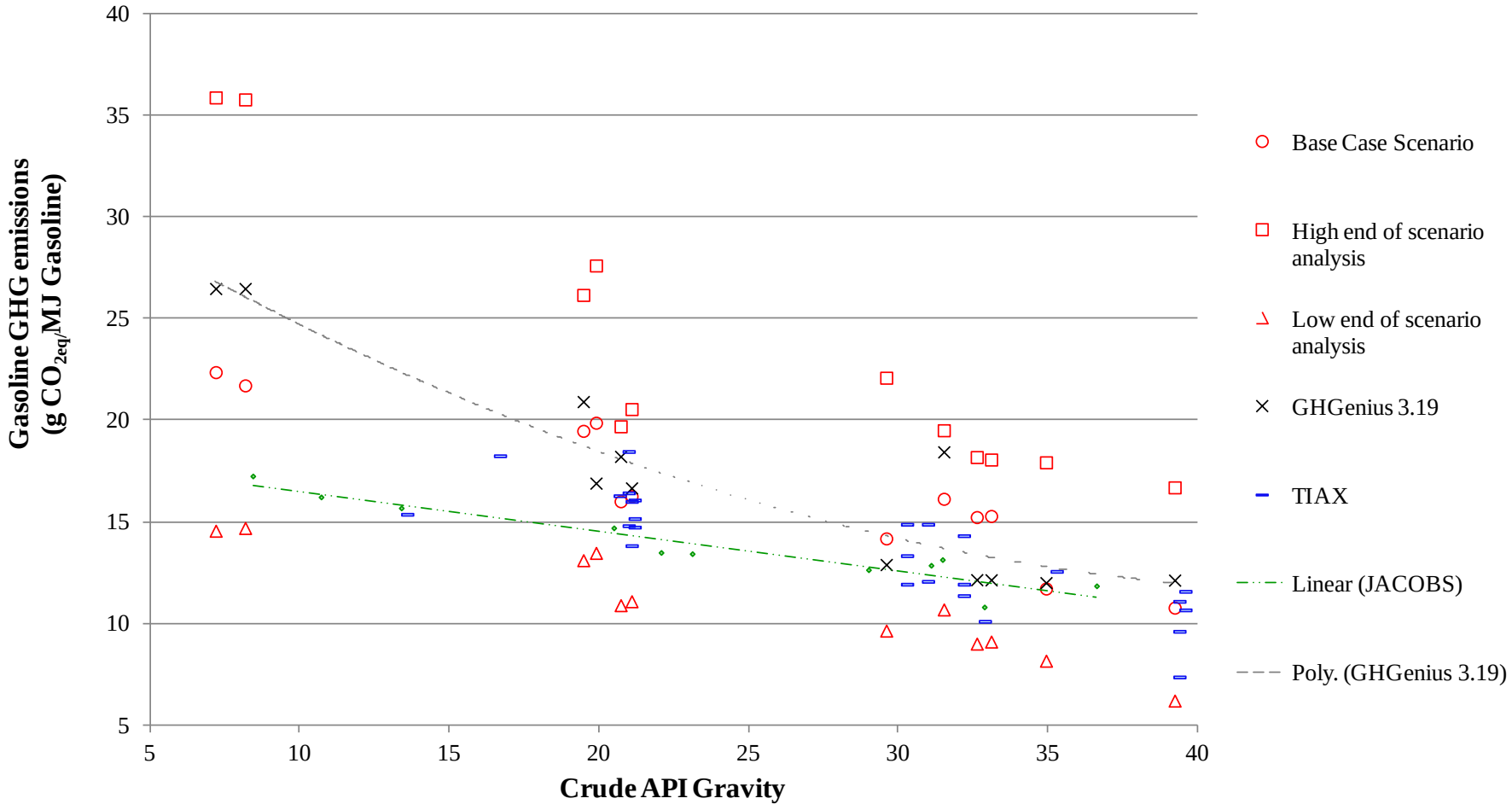
# Refinery Configurations in PRELIM



# Ongoing Model Evaluation

- Industry Standard Tools
  - PRISM
  - HCAMS
- Individual refineries in the US
- Process unit comparisons
- H consumption methods
  - (e.g., kinetic models)
- Macro emissions estimates from different studies, EPA etc.

# Refinery GHG Emissions to Produce Gasoline




Abella and Bergerson. ES&T. 2012

# Recent/Current Additions to the Model

- Blending tool
- Fixed capacities
- Evaluation of emerging technologies
- Fixed vs. Float cases
- Additional configurations
- Adding crudes to inventory (now more than 100 crude assays) – still missing important assays!
- Better differentiation of product slate properties
  - Asphalt
  - LPG
  - Bunker fuel

# Factors that affect product slate volumes

- Crude blend feedstock
- Process unit capacities
- Process unit configuration

- Diversions of streams within the refinery
- Product quality specifications

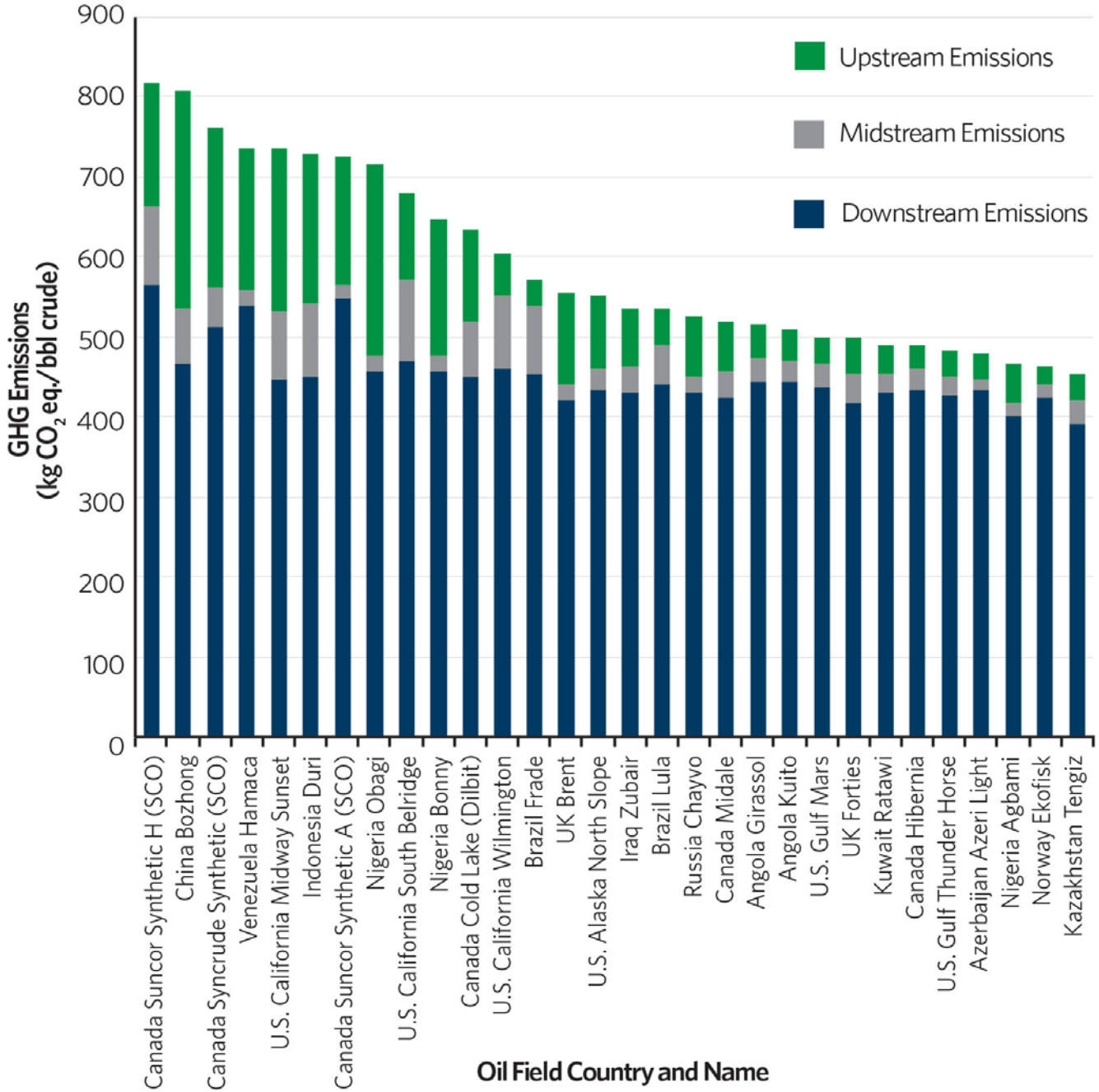
# Applications of PRELIM

- Carnegie Endowment for International Peace's Oil Climate Index
  - http://oci.carnegieendowment.org/
- US Petroleum Baseline for 2014
- Inform investors

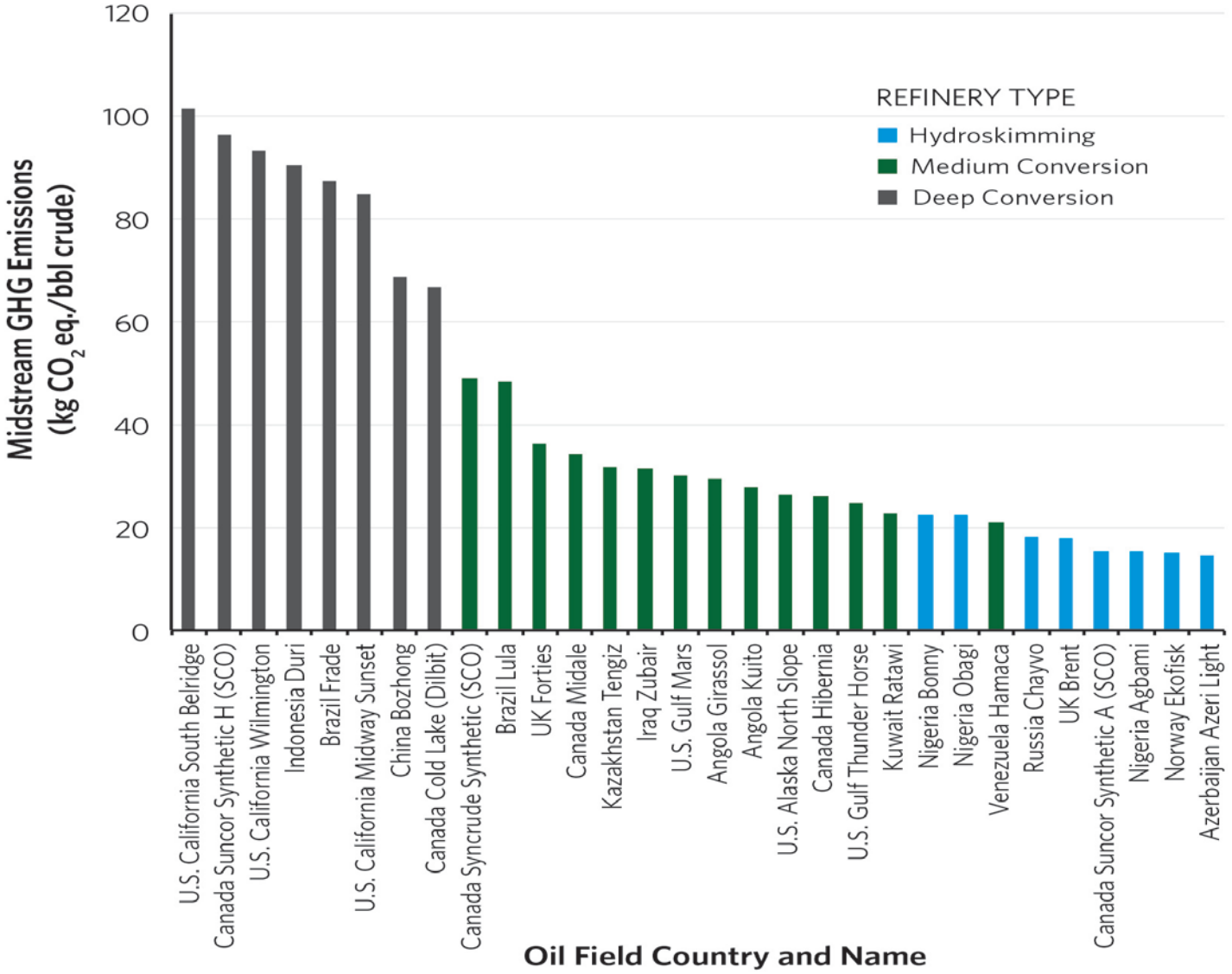
# The Oil Climate Index

- Phase 1 - 30 test crudes (phase 2 will be 75 crudes)
  - selection based on available data
  - Represent every major global region, 4.5 million bpd, 5% of global production
- 3 open-source models using all public data
  - Upstream - OPGEE – Adam Brandt at Stanford
  - Midstream – PRELIM – Joule Bergerson at UofC
  - Downstream – OPEM – Deborah Gordon at CEIP
- Data a key challenge

## Total GHG Emissions for 30 Phase 1 OCI Test Oils



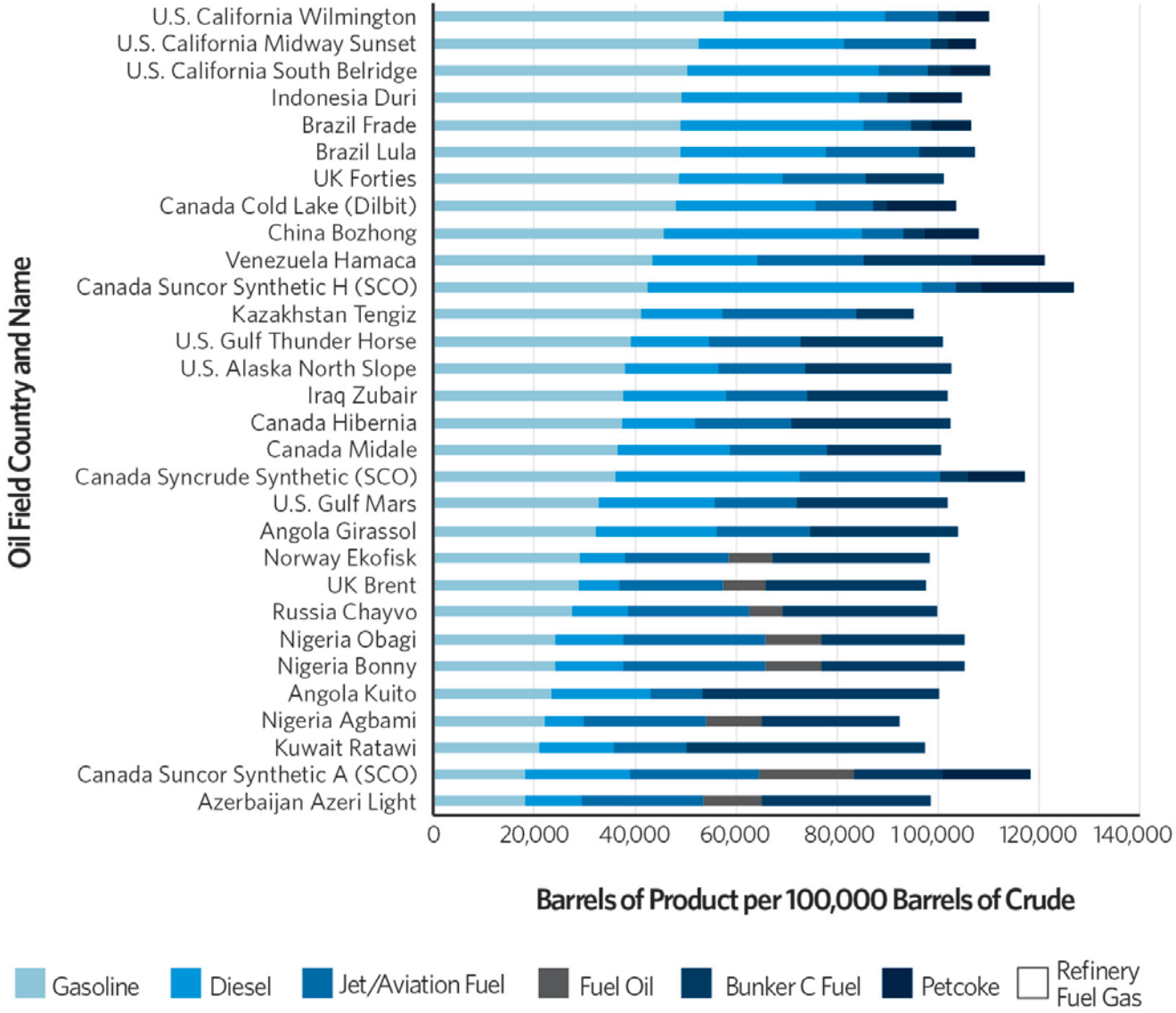
**PRELIM GHG Emission Results for 30 Phase 1 OCI Test Oils**




Source: Authors' calculations

Notes: The 30 test oils were run through a delayed coking refinery as well. Hydrocracking facilities are also possible to model in PRELIM. Medium and deep conversion refineries use fluid catalytic cracking (FCC) and gas oil-hydrocracking (GO-HC) processes. Unlike the other OCI test oils, Cold Lake dilbit is not composed of a full barrel of oil.

## PRELIM Product Outputs for 30 Phase 1 OCI Test Oils




Source: Authors' calculations

Notes: Petcoke production is total for refinery (for heavy oils) and upstream upgrading (for SCO). PRELIM currently assumes all refinery fuel gas (RFG) is used in the refining process. Unlike the other OCI test oils, Cold Lake dilbit is not composed of a full barrel of oil.

## Drivers of Midstream GHG Emissions for 30 Phase 1 OCI Test Oils

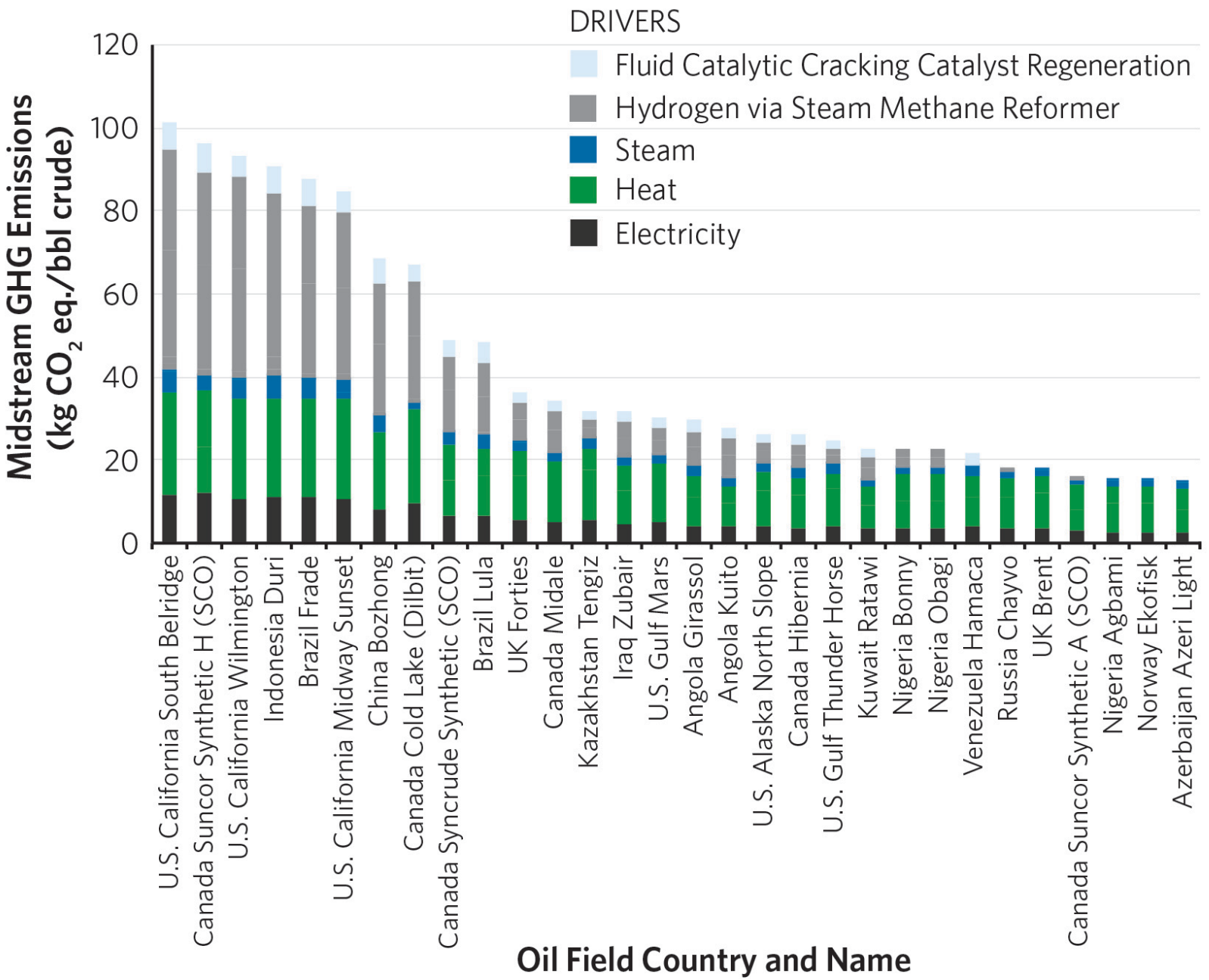
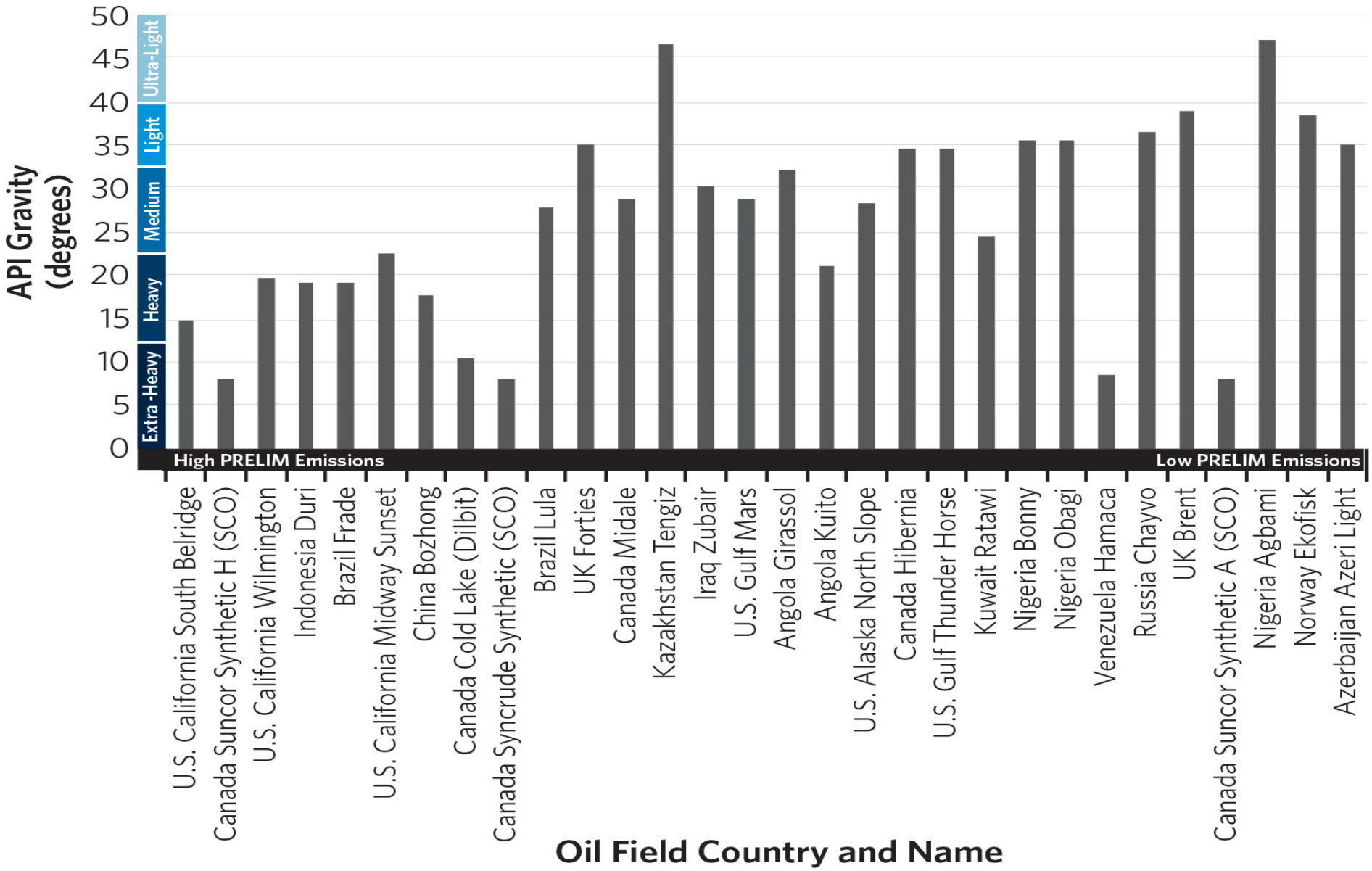


FIGURE 8

## API Gravity of 30 Phase 1 OCI Test Oils in Order of PRELIM GHG Emissions




Source: Authors' calculations

# Insights to Date

- Crude quality and refinery configuration still remain the biggest driver of emissions
- H consumption within the refinery differentiates emissions between crudes
- Data, data, data

# Future Research Priorities

- More and better data – examples:
  - Eagle Ford assays
  - Shifts in product slates from refineries
- Statistical analysis to explore variability and uncertainty of refinery operations and GHG emissions
- Ongoing evaluation of the model

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# Thank you!

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www.ucalgary.ca/lcaost/prelim

http://oci.carnegieendowment.org/