Co-processing in Petroleum Refineries: 3rd Work Group Meeting

Transportation Fuels Branch
Industrial Strategies Division

June 2, 2017
Sacramento, CA

California Environmental Protection Agency
Air Resources Board

Agenda

- Welcome
- Review core objectives of the work group
- Staff presentation
- Feedback from previous meetings
- Invited expert presentation
- Discussion
- Next steps

Core Objectives of the Work Group

- Establish guidelines for quantification of low carbon fuel volumes from co-processing
- Evaluate greenhouse gas emissions of co-processing operations and corresponding carbon intensities of low carbon fuels produced
- Develop guidelines to facilitate certification of carbon intensity for co-processed low carbon fuels
- Develop monitoring and verification protocols for co-processed fuels

Draft Discussion Paper-Update

- Streamlining approaches for quantification of low carbon fuel content and estimating GHG emissions of low carbon fuels from co-processing
- Illustrative examples for estimating GHG emissions from co-processing in FCC and hydrotreater units
- Literature review (Appendix)

Co-processed Fuel Pathway Certification Process

- Will be handled as Tier 2 Fuel Pathways
  - ❑ Complexity of co-processing operations, mixed feedstocks and challenges in quantification of CI and fuel volumes
  - ❑ New quantification methods supplement the CA-GREET framework
- Subject to all applicable requirements for Tier 2 pathways described in Section 95488 of the LCFS regulation
- Operating conditions may be listed during certification of each co-processed fuel pathway

Quantification of Low Carbon Fuel Yields

Framework for Low Carbon Fuel Yield Quantification

- Staff working towards streamlining approaches to quantification of low carbon fuel yields
- Proposal under consideration requires applicant to:
- Provide actual material input and output data (material balance data)
- Quantify low carbon fuel yields using either of the following methods
  - ❑ Mass Balance based on Observed Yields
  - ❑ Carbon Mass Balance Method

Low Carbon Fuel Yield Quantification Option 1 – Mass Balance Based on Observed Yields

- Compare product-specific observed yields in the co-processing (fossil plus low carbon feedstocks) case to yields in the 100% petroleum feedstock (baseline) case

$$LCM_i = CM_i - (M_p \times Y_i)$$

where,

$\mathbf{LC}M_i$	=	Mass of i^{th} low carbon fuel product produced from co-processing
CM_i	=	Mass of i^{th} fuel (low carbon + petroleum) produced from co-processing
M_p	=	Mass of petroleum feedstock used in co-processing
Y_i	=	Specific yield of i^{th} fuel in baseline (kg of i^{th} fuel/ kg of petroleum feedstock)

A detailed illustration is provided in the template for co-processing in hydrotreating units. https://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/lcfs_meetings.htm

Low Carbon Fuel Yield Quantification Option 2 – Carbon Mass Balance

- Determine the carbon content of biogenic feedstocks
- Determine the amount of biogenic carbon lost as CO and CO_2 during processing
- Estimate renewable carbon correction factor for biogenic feedstock
- Apply renewable carbon correction factor to produced fuels to estimate the amount of low carbon fuels

$$RM_i = \frac{M_{biomass}}{M_{total}} \times CM_i \times \%R_F$$

Where,

RM_i	=	Mass of i^{th} renewable fuel from co-processing
$M_{biomass}$	=	Mass of biogenic feedstock (dry basis)
M_{total}	=	Total mass of feedstock co-processed (petroleum + biogenic)
CM_i	=	Mass of i^{th} fuel from co-processing
$\%R_F$	=	Renewable carbon correction factor (%)

This method is applicable to biogenic feedstocks

Low Carbon Fuel Yield Quantification – Next Steps

Are there issues/concerns with the quantification options presented here?

Would stakeholders like to suggest alternate approaches?

What data could be offered in support of selecting one or more methods of quantification?

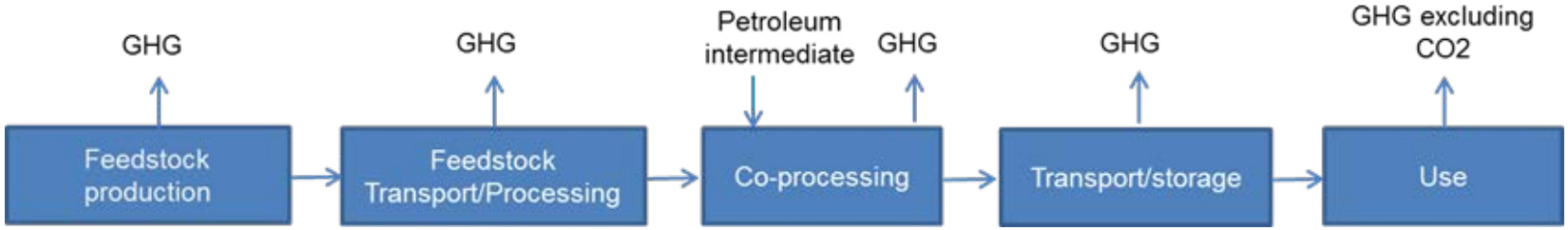
Is requiring three months of production data for each (with and without co-processing) in Option 1 for provisional pathways reasonable?

Is requiring three months of production data for co-processing in Option 2 for provisional pathways reasonable?

Estimation of GHG Emissions

LCA Methodology

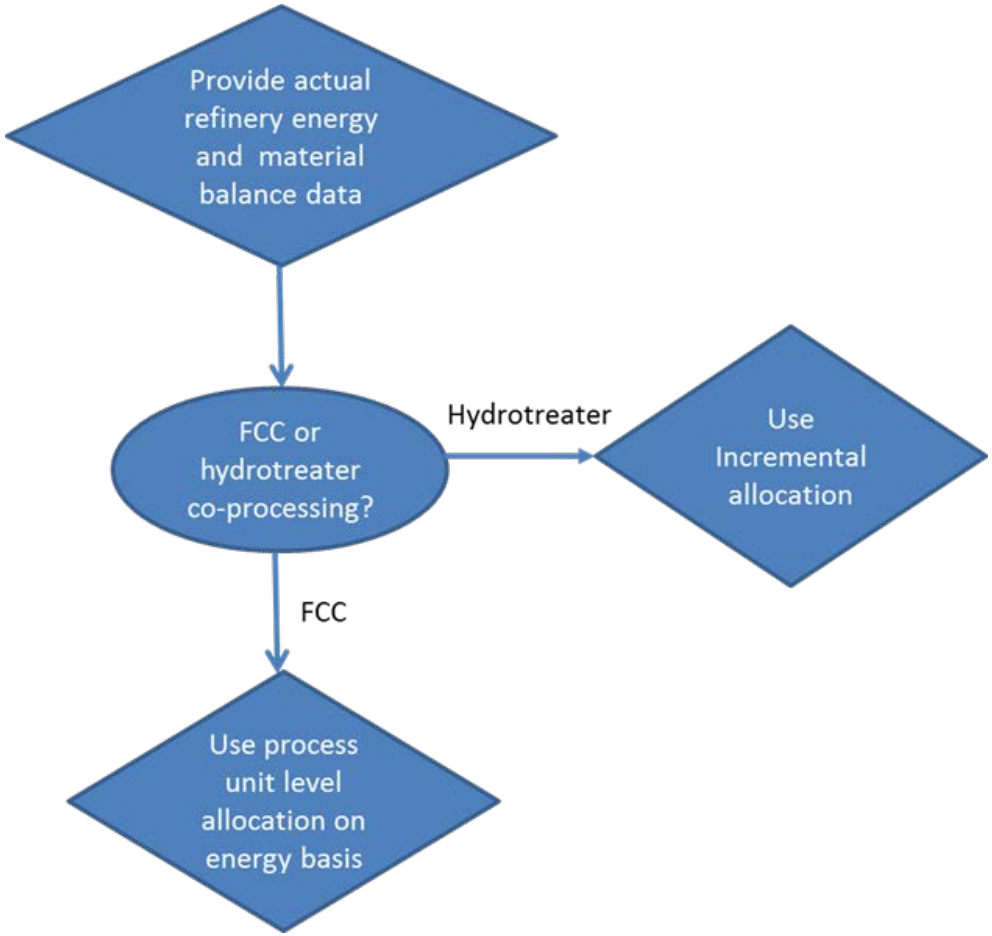
- Covers well-to-wheel GHG emissions including direct and indirect emissions



- Except for the co-processing step, GHG accounting methods are similar to typical biofuel pathways

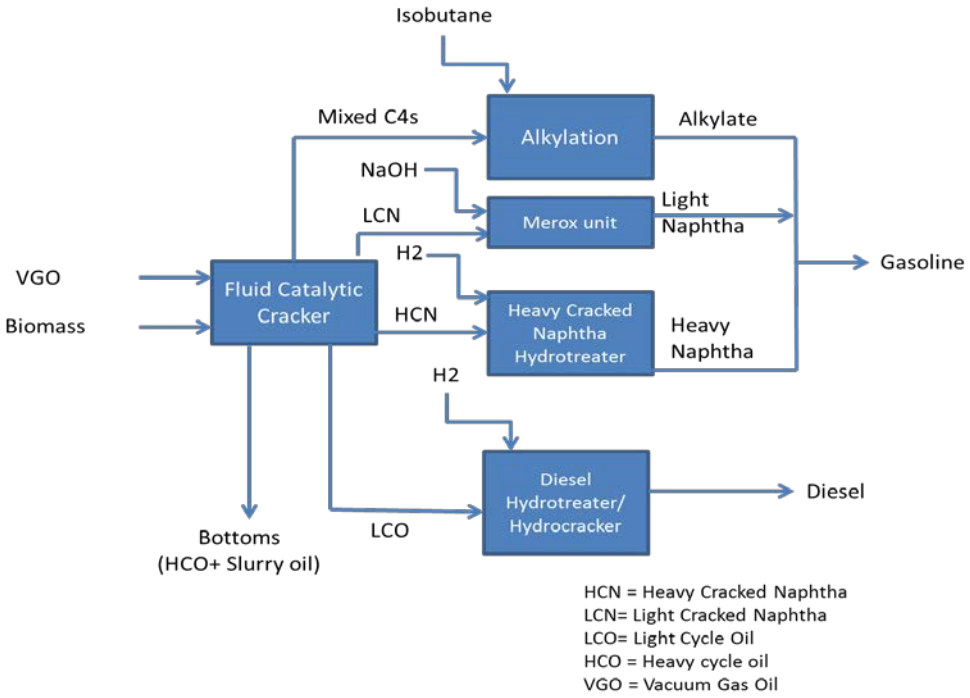
- Work Group discussion focuses on co-processing GHG emissions only

Refinery Carbon Intensity Quantification Framework



GHG Emissions Quantification: Co-processing in FCC Units

- Step by step unit level allocation on the units receiving FCC renewable streams

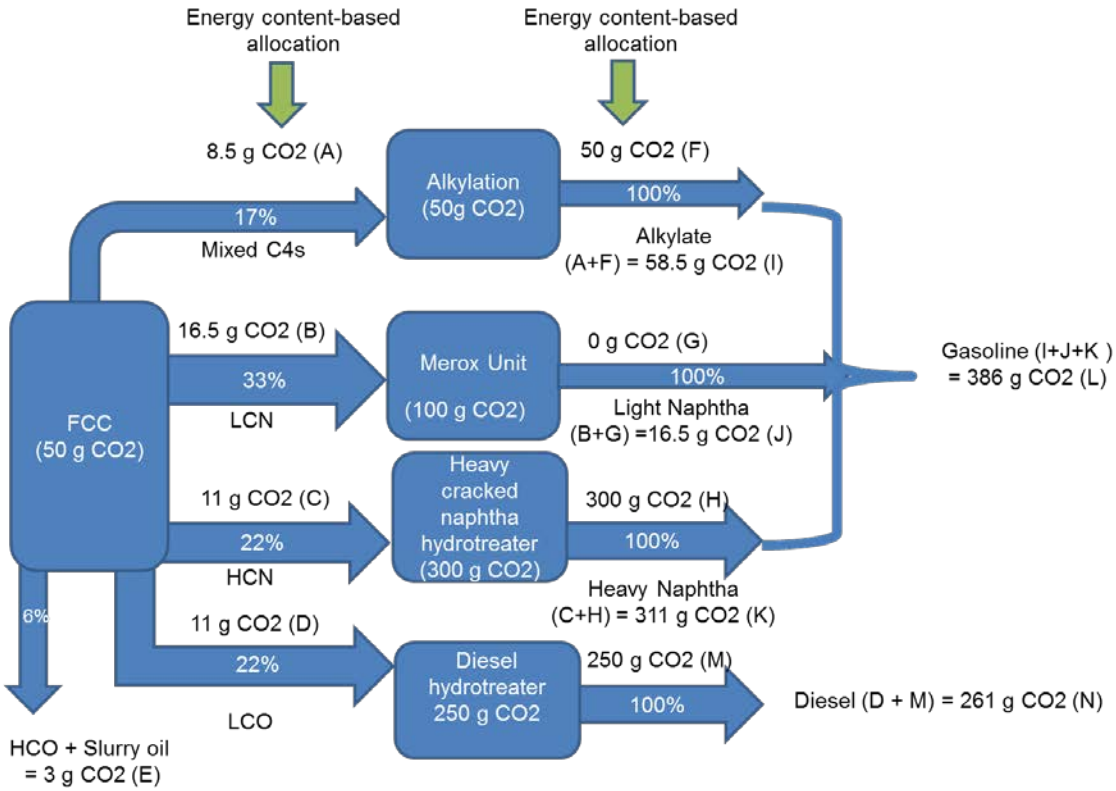


Illustrative FCC Allocation System Boundary

Process Unit Level Allocation: Co-processing in FCC Units

- Process unit level allocation based on energy content
  - GHG emissions from the co-processing unit attributed proportionally to the fuel product outputs based on energy content of an individual output relative to the total energy content of all outputs
  - Starts with the unit at which low carbon feedstock is introduced, and is carried through subsequent process units used to produce low carbon fuels
  - Simple illustrative example in draft discussion paper
  - Detailed calculations and illustration provided in the template for co-processing in FCC units posted online http://www.arb.ca.gov/fuels/lcfs/lcfs_meetings.htm

Process Unit Level Allocation Scheme

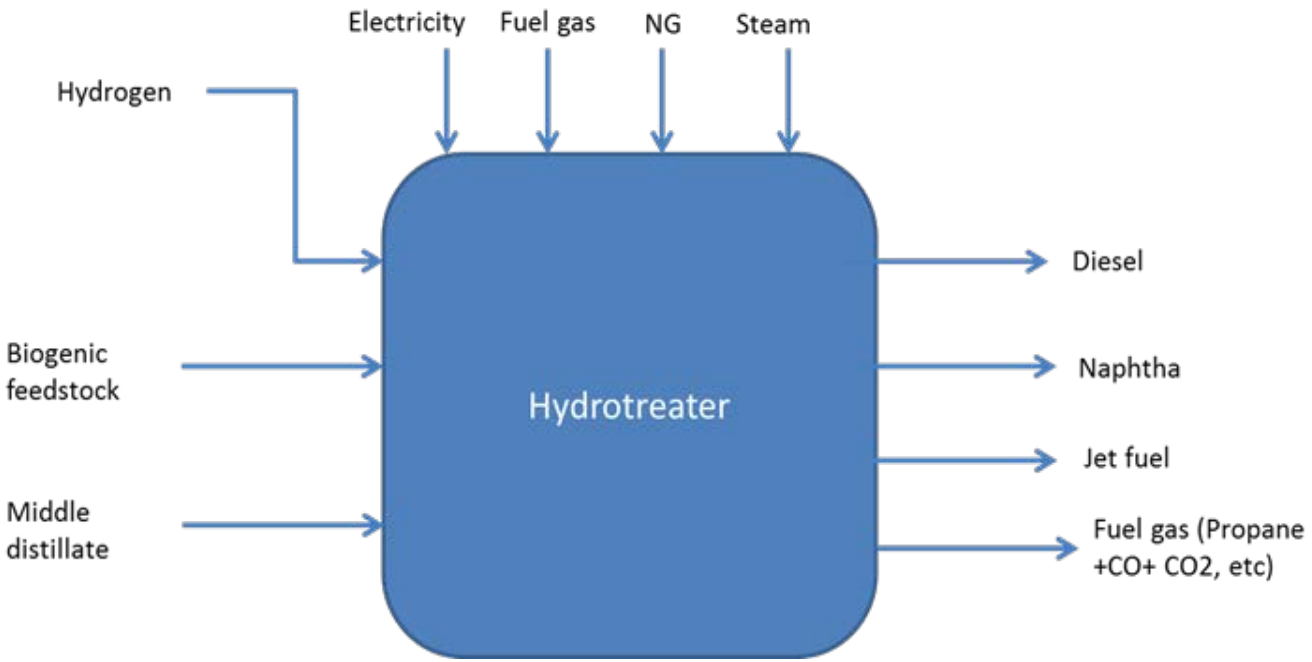


Illustrative Allocation Scheme for a FCC Unit

Incremental Allocation: Co-Processing in Hydrotreating Units

- Incremental allocation approach
  - ❑ preferable for co-processing in hydrotreating units because of substantial increase in hydrogen use relative to baseline
  - ❑ Simplified example detailed in draft discussion paper
  - ❑ Detailed calculations and illustration provided in the template for co-processing in hydrotreating units posted online. http://www.arb.ca.gov/fuels/lcfs/lcfs_meetings.htm

System Boundary: Co-processing in Hydrotreating Units



Illustrative System Boundary for a Hydrotreating Unit

Incremental Allocation Approach: Co-processing in Hydrotreating Units

$$GHG_{LCF} = GHG_{cp} - (M_p \times Y_i)$$

where,

GHG_{LCF}	=	Incremental GHG emissions associated with low carbon fuel
GHG_{cp}	=	GHG emissions of i^{th} fuel (low carbon + petroleum) produced from co-processing
M_p	=	Mass of middle distillate used in co-processing
Y_i	=	Specific emissions per unit middle distillate processed in the baseline (kg CO_2e/ kg-middle distillate)

GHG emissions – Next Steps

Are there issues/concerns with the GHG estimation framework presented here?

Would stakeholders like to suggest alternate approaches not considered here?

What data could be offered in support of selecting one or more approaches for CI estimation?

Co-processing Renewable Hydrogen in Refineries

- Initially included as part of co-processing discussion
- Stakeholder Feedback: more appropriate to address renewable hydrogen co-processing under the existing Renewable Hydrogen Credit Pilot Program
- Staff is proposing to make amendments to the Renewable Hydrogen Credit Pilot Program

Proposed Amendments to Renewable Hydrogen

- Simplifying credit calculations for steam methane reforming (SMR) by directly comparing the carbon intensity of natural gas with that of renewable natural gas
- Introducing flexibility in the framework to capture all possible renewable hydrogen pathways, including solar electrolysis
- Details on amendments included in the draft discussion paper posted online

https://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/lcfs_meetings.htm

Preliminary Thoughts on Monitoring and Verification

- **Biomass feedstock supply**: Monitoring and verification requirements are expected to be similar to renewable diesel/biodiesel pathways
- **Refining:** Documentation of refinery energy use within the co-processing system boundary, feedstock use and fuel production data, and isotopic analysis for qualitative verification of renewable content
- **Fuel supply:** Staff recognizes the need to account for supply of out-of-state co-processed fuels

Co-processed Fuel Supply from Out-of-State Producers

- Comingled fuel - impossible to physically segregate at the co-processing facility
- Stakeholder proposal: Supply chain material balancing
  - ❑ Assigns the renewable fuel output from the co-processing facility to gallons of fuel supplied to California
  - ❑ Actual molecules not tracked and renewable content in delivery may be different physically
  - ❑ Similar to what is currently permitted for comingled high and low CI biofuels

Are there issues/concerns with the supply chain material balancing approach described here?

Feedback from Previous Meetings

- General support for mass-balance-based approach for quantifying low carbon fraction of fuels
- Concerns over C^{14} analysis
- Preference for illustrations of low carbon fuel content and CI estimations examples based on schematics that reflect real-world refinery processes
- Allowing computer modelling calibrated to actual operating data for estimating yields and energy inputs

Feedback (cont.)

- Defining an acceptable tolerance range for CI during verification (e.g., +/- 5%)?
- Frequency of CI validation during provisional status
  - ❑ Semiannual vs. annual?
  - ❑ No penalty or action during provisional status if the validated CI is different?
- Treatment of renewable hydrogen under the Renewable Hydrogen Credit program, not as part of co-processing
- Consideration of supply chain material balancing for out-of-state co-processed fuel producers

Questions?

Expert Presentation

Tracking Renewable Carbon for Bio-oil Co-processing Using 13C/12C Ratio

Zhenghua Li, Ph. D.

Los Alamos National Laboratory

Next Steps

- Additional work group meeting
  - ❑ September 2017
- For discussion at the next meeting
  - ❑ Review feedback from stakeholders
  - ❑ Update guidance document on low carbon fuel quantification and carbon intensity estimation
  - ❑ Guidelines related to monitoring and verification

Next Steps (cont.)

- Stakeholder inputs requested on:
  - ❑ Streamlining the proposed quantification and CI estimation methods
  - ❑ Potential process units for co-processing
  - ❑ Are there data from trial production runs to support this effort?
  - ❑ New research reports on renewable mass quantification and LCA methods
  - ❑ Barriers to deployment of co-processing
  - ❑ Challenges to reporting and verification of finished fuels
  - ❑ Other comments to assist with objectives of this work group

Feedback

Feedback related to Co-processing Work Group Discussions should be sent to:
LCFSworkshop@arb.ca.gov
by July 5, 2017

Presentations, draft discussion paper and co-processing excel templates available at:
http://www.arb.ca.gov/fuels/lcfs/lcfs_meetings.htm