Air Pollutant Emissions and Regulatory Implications of Co-processing Raw Bio-oil in U.S. Petroleum Refineries

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Introduction

- Studies have shown that the U.S. has abundant low-cost biomass feedstock available for renewable fuel production.
- Pyrolysis oil, often referred to as bio-oil or biocrude, has higher energy density compared to raw biomass.
- Co-processing raw bio-oil with vacuum gas oil (VGO) in fluid catalytic cracking (FCC) unit of a petroleum refinery could be a viable option to leverage existing infrastructure to produce partially renewable fuels.

Context

- New Source Review (NSR) program requires a facility to obtain a construction permit before new construction or modification that will result in net increase in emissions (potential to emit (PTE)).
- Although retrofitting refineries to co-process raw bio-oil is not capital intensive, obtaining required air permits could be time consuming.

Research objectives

- Gain insights into the process and operational changes required for co-processing
- Estimate potential increase in PTE for 5 wt% raw bio-oil co-processed with 95 wt% VGO
  - Determine source classification
  - Assess applicability of federal regulations
- Assess technically feasible emission control options to avoid major modification permitting

Relevance

- Petroleum refineries, bio-oil producers, air quality planners, regulatory agencies, and sustainability community

Key messages

- Co-processing is a near-term options to
  - Provide synergies between refineries and biofuel producers
  - Produce infrastructure compatible renewable hydrocarbon fuels with lower carbon intensities at minimal capital requirement
- 88 of 95 FCC-equipped refineries can co-process 5wt% of raw bio-oil without requiring major permits.
  - Co-processing threshold for major modifications: ≤8,400 bbl/day
  - Control technologies are available to reduce emissions for larger co-processing rates
  - 6 refineries in California (LA-South Coast Air Basin) cannot co-process any raw bio-oil (extreme ozone nonattainment area)
- Our analysis integrates engineering analysis with regulatory assessment to facilitate informed decision making about bio-oil co-processing in existing refineries.

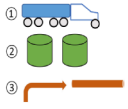
Methods –

Step 1: FCC unit size categories

FCC Capacity* (barrels per day)	Bio-Oil Volume (barrels of raw bio-oil per day)	Number of Refineries
≤27,850	≤1,100	32
>27,850 and ≤68,350	>1,100 and ≤2,700	31
>68,350 and ≤232,500	>2,700 and ≤9,200	32

* https://www.eia.gov/petroleum/refinerycapacity/refcap16.pdf

Step 2: Process modifications for co-processing raw bio-oil at petroleum refineries

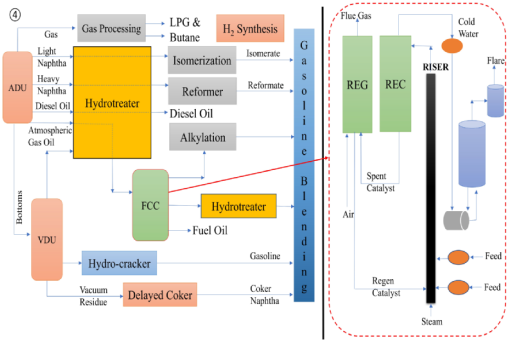


① Truck transport for shipping raw bio-oil

② Raw bio-oil storage tanks

③ Additional piping equipment

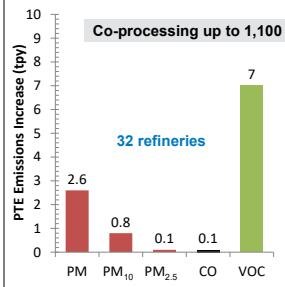
④



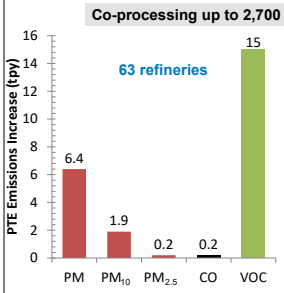
Step 3: Estimate emissions and determine regulations and permitting implications

- Emissions from AP-42 database, source specific models such as TANKS 4.09D (assuming Houston, TX location), and material balance (for emissions due to shift in product distribution)
- Review the applicability criteria for each federal rules under New Source Performance Standards (NSPS) and National Emission Standards for Hazardous Air Pollutants (NESHAP)
  - NSPS is codified in Title 40, Part 60 of the Code of Federal Regulations (CFR).
  - NESHAP is codified in Title 40, Parts 61 and 63 of the CFR

Results – PTE Emissions Increase



- Emissions below SER for all regulated pollutants
- Straightforward **minor NSR** permit would be needed



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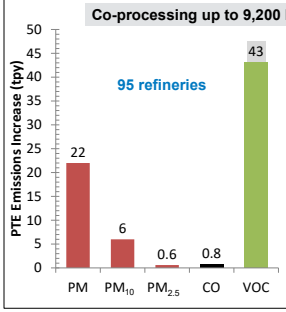
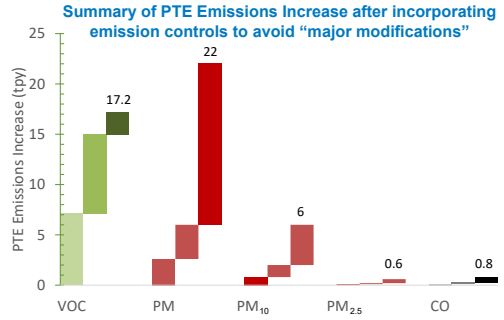


- Emissions below SER for all regulated pollutants except **VOC**
- **PSD or NNSR major** modification permit would be needed, unless VOC emissions are reduced below major modification threshold of 40 tpy



Results – Federal Regulatory Analysis

- No additional NSPS or NESHAPs apply to new equipment at the refinery.
- Adding new equipment will not make any existing process units subject to any of the regulations.
- Same leak detection and repair (LDAR) requirement apply to additional piping equipment added for bio-oil co-processing.

Limitations

- Lack of information on bio-oil physio-chemical properties
  - E.g., vapor pressure as a function of temperature
- No state or local regulations considered
- Uncertainty in quantifying renewable content in the final gasoline and diesel products
  - Lack of approved methods to estimate renewable content
  - Lack of experimental data on renewable distribution among FCC products

References

1. Bhatt A, Zhang Y, Heath G. Bio-oil co-processing can substantially contribute to renewable fuel production potential and air quality standards. In review at Applied Energy. 2019.
2. Pinho A de R, de Almeida MBB, Mendes FL, et al. Fast Pyrolysis Oil from Pinewood Chips Co-processing with Vacuum Gas Oil in an FCC Unit for Second Generation Fuel Production. Fuel. 2017 Jan 15;188:462–73.
3. CARB (California Air Resource Board). Co-processing of Biogenic Feedstocks in Petroleum Refineries. 2017. https://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/020717_staffdiscussionpaper.pdf.

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