Steeper Energy biocrude coprocessing customer (refiner) discovery & market overview - Highlights from MBA capstone project at University of Calgary

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(the opinions expressed are the author's interpretation of information from literature and interviews with industry experts)

Highlights

- Canadian Oil&Gas sector characteristics
  - very concentrated (>70% in 4 companies)
  - slim and fluctuating margins
  - owns supply chain
- Refiner co-processing concerns
  - Volume and cost of biocrude
  - Offtake agreements (duration and tied to petro-index)
  - Turnaround and capital projects duration
  - Refineries are different – metallurgy – complexity (hydrocracking vs FCC capacity)
- Positive market signals from high demand for renewable diesel (HRD)
  - Low carbon fuel commitments increasing and marine – aviation entering
  - Traditional biodiesel and electrification limitations
  - Diesel demand increasing vs. gasoline leveling off

Conventional solutions (efficiency, FAME, ethanol, HRD) have limited room to grow

Biocrude co-processing very attractive but unknown technology risk

	Demand destruction	Entering non-petroleum feed markets	Growth limitations	Technology Risk	Cost
Process efficiency	No	No	Efficient already	Low	Medium
Ethanol	Yes	Yes, unless own	Shortage & blend wall	Low	Low
FAME	Yes	Yes	Shortage & blend wall	Low	Medium
HRD	Yes	Yes	Shortage of Low CI FOG	Low	High!
Co-refine FOG	No	Yes	Shortage of low CI FOG	Medium	Low
Co-refine Biocrude	No	Yes	Few	High/ unknown	Low
CCS	No	No	Infrastructure	High	High!

- Process efficiency favored but little room for growth
- CCS: no need to enter other markets but high cost
- Ethanol and FAME: blend walls
- HRD: shortage and cost

- Co-refining FOG (fats, oils, greases) is favored but shortage of feedstock
- Co-refining Biocrude is a big unknown but feedstock sustainability and availability attractive

What integration pathways are being considered?

FCC is easier for refiners but Hydrocracking produces higher yields of liquid fuels

	Catalytic Cracking (FCC)	Hydrocracking
Handling of oxygen	High (goes to catalyst regenerator)	Low (can "poison" fixed bed catalyst)
Favoring diesel production	No (favors gasoline)	Yes (upgrades heavy oils into distillates)
Suitable for "cyclical" (aromatic) feeds	No (aromatics favor gas and coke formation)	Yes (Hydrogen is used to saturate and open aromatics)
Downstream issues	No (contaminants are handled in FCC regeneration)	Yes (oxygenated gases and contaminants report downstream)
Favored if	Inaccurate biogenic C tracing	Accurate biogenic C tracing (e.g. ^{14}C isotope tracing)
Available capacity due to	Increasing idle FCC, especially in the US	Increasing ULSD demand

- Choice of pathway will depend on the refinery structure, properties of the oil (e.g. aromatics & contaminants), risk strategy of refiner and low carbon fuel policy
- Hydrocracking favored for biocrude co-processing in order to maximize recovery of biogenic carbon in liquid product

Markets complex, certification pathways needed

Engage early with certification bodies and LCFS regulators
Understand the strategic fit of biocrude in the complex market

- Ability to trade product (fuel) but the recognition of CI value is different in each jurisdiction (arbitrage opportunities and trade complexity)
- Ensuring recognition of pathway by different LCFS programs is key:
  - No current biocrude pathway recognized (with CI assigned) by any of the LCFS systems (except Ensyn has an indicative CI under CARB).
  - The design of various LCFS regulations will affect the CI recognition
- No system to trade credits between jurisdictions
- Ensuring technical fuel standard recognition (e.g. CGSB)
  - It is challenging for new fuels and the process costs a lot of money and time
  - It is hard for certification boards (e.g. CGSB) to justify the resources when there is uncertainty around technologies and pathways
- Collaboration with refiners needed for certification or co-processed fuel

Conclusions

	Favourable	Unfavourable
Industry	• GHG regulation is tightening and the view is that low CI compliance is here to stay • Strong strategic appetite for Big Oil to be producers of drop-in biofuels (e.g. Ren. Diesel)	• Risk averse, slim & variable margins, little room for innovation, high regulation, focus on efficiency gains. • Low familiarity with biocrude
Competing solutions	• HRD gaining tremendous traction, indicates difficulties with FAME, Ethanol, and electrification	• CFS: Co-processing clustered in bucket 1 along with refinery process efficiency
Refinery integration	• High refiner appetite due to regulations and expensive, or hindered renewable blendstocks	• Complexities with operational and risk sharing arrangements – require collaboration • Refineries are very different in equipment, compliance obligation, and strategy

Fuel Markets	• Numerous jurisdictions are ramping up low CI fuel commitments
	• Demand is growing fast, especially for HRD equivalent product
	• Need to ensure low CI market for heavy ends
	• Low-carbon price premium
		• Markets will be complex and diverse, need:
		  • pathway recognition (low CI)
		  • and fuel certification (e.g. CGSB)
		  • Collaboration with refiners needed for certification or co-processed fuel