Techno-Economic Evaluation of Renewable Jet Fuel from Softwoods: The NARA Greenfield Integrated Biorefinery Process

Tom Spink, Gevan Marrs, and Allan Gao
November 17, 2016

NARA Summary Conference, Washington DC
Embassy Suites, Crystal City
TEA Overview

• Commissioned to assemble detail from all the relevant conversion teams, design an integrated, full-scale N\textsuperscript{th} plant facility, estimate all Capex, Opex, Revenue, and perform a DCF-ROI analysis

• Estimated process parameters, yields, inputs, etc, from all process steps

• Integrated all steps into overall process flow.

• Built ASPEN mass and energy balance to define materials and energy.

• Obtained cost estimates for capital equipment, installation, facility costs.

• Obtained data for operating costs.

• Assembled into a Discounted Cash Flow analysis
IBR Process Flow Overview

NARA Base Case Greenfield Integrated Bio-Refinery - Process Overview

1. Feedstock Handling
2. Mild Bisulfite Pretreatment
3. Enzymatic Hydrolysis
4. Fermentation to IBA & Conversion to IPK
5. IPK Storage & Distribution
6. Lignin Co-products
7. Hog Fuel and Natural Gas Boilers
8. Utilities

- Softwood Forest Harvest Residuals
- Lignosulfonates
- Activated Carbon
- Isoparaffinic Kerosene
IBR Base Case Key Specifics

- Hypothetical siting in Longview, WA, (best location)

- Feedstock is 846,000 BDST/yr. softwood forest harvest residuals, (2,200 BDST/day)

- Facility output is:
  - 35,700,000 gal/yr. isoparaffinic kerosene (jet biofuel)
  - 196,224 tons/yr. lignosulfonates
  - 66,192 tons/yr. activated carbon

- Full scale, greenfield, Nth plant, not pioneer or demonstration scale

- 30-year facility life, 10% discount rate, MACRS depreciation, 100% equity financing, solve for minimum selling price of IPK to get zero NPV.
Results

- Total Capital Investment; $1,100 MM
- Annual Operating expense; $248 MM/yr.
- Revenue:
  - Lignosulfonates: $39 MM/yr.
  - Activated Carbon: $99 MM/yr.
  - Isoparaffinic Kerosene: $261 MM/yr. (to achieve 10% IRR)
    - IPK MSP total is: $7.31/gal IPK
      - Petro-jet projection: $2.56/gal IPK
      - RINs projection: $2.46/gal IPK
      - Needed additional: $2.29/gal IPK
- Conclusion
  - Current projected prices for IPK and RINs would only return ~3.6% IRR. Need a total “biofuel premium” of about $4.75/gal IPK to achieve 10% IRR.
Comparison to other pathways

• DOE BETO MYPP NREL TEAs are the most up-to-date, fully developed biofuels TEAs.

• For woody feedstock to hydrocarbons (gasoline and diesel), using current state of technology, the NREL MSP values are; (per/GGE)
  
  – 2013 Woody feedstock via biologic conversion of sugars to hydrocarbons: $12.97
  – 2015 Woody feedstock via Fast Pyrolysis to hydrocarbons: $6.47
  – 2015 Woody feedstock via catalytic conversion of sugars to hydrocarbons: $7.29

• NARA Softwood to IPK similar at MSP $7.31/gal IPK
  
  – However, state of technology more advanced for many NARA process steps
• Thank you for your time today

• Questions?