Natural Gas Enhanced Biofuels

Review and Preliminary Economics

August 16, 2012
Comparison of Biofuel Production Pathways*


![Bar chart showing gallons of ethanol equivalent biofuel per ton of biomass for different production pathways]
Low biofuel yield makes economic viability challenging.
Natural Gas Enhanced Process

- Addition of H₂-rich syngas from natural gas
  - Increases liquids yield per ton of biomass
  - Decreases lifecycle CO₂ emissions – qualified under EPA RFS 2
- Reduces technical risk
  - Uses technology proven at scale
  - Adjusting H₂/CO ratio upward is always beneficial
- Start-up with SMR; higher availability

> 2X production; 40% more capital
Estimated Project Economics

- **Feeds & Product Slate**
  - **Feeds**
    - 900 t/d of bone dry wood
    - 11 MM SCFD of natural gas purchased
  - **Product Slate - 90% of nameplate**
    - 2,000 bbl/d (84,000 gal/d) – FT liquids
    - 14.5 MW of Green electric power sold to grid

- **Costs**
  - CAPEX - $300MM ($150,000/bbl/day)
  - Wood @ $40/Bone dry ton
  - Natural gas @ $5.00/MM Btu (HHV)
  - Electric power export @ $70/MWh (premium green power)

- **Financial Assumptions**
  - Income tax rate @ 30%
  - 100% equity financed
  - 10 year economics
Projected IRR

- CAPEX, $/bbl/day
- Fuel Price + Credit, $/gal
- Wood Price, $/bone dry ton
- Natural Gas, $/Mcf
- Power Credit, $/MWh
IRR as a Function of Oil Price

Based on the following correlation relating diesel prices to WTI:

\[ Y = 0.029(X) + 0.022 \]

where: \( Y \) – $/gal refinery diesel price; \( X \) – $/bbl WTI price