Commercialization of IH²®
Biomass Direct-to-Hydrocarbon Fuel Technology
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The “Valley of Death”

Technical Success
when you demonstrate a brilliant idea

Commercial Success
when you get someone to build a second plant
Building the Bridge to Commercial Success

- Use existing reactor / process technologies where possible
- Deliver a fungible or infrastructure compatible product
- Utilize broad range of feeds
- Be self-sufficient / stand alone if needed / integrate for savings
- Demonstrate over multiple scales
- Circumnavigate troubled waters (e.g. ‘food vs. fuel’)
- Be economic vs. fossil fuel
- Know and engage key stakeholders
- Formulate entity-specific CVPs
- Partner early
- Mitigate risks
The IH²® Process Developed by GTI

**Feed**
- City Waste
- Crop Residue
- Wood/Forest Residue
- Energy Crops
- Algae

**Process**
1) Feed Conditioning
   - Sizing, Drying & Feeding
2) Fluidized Bed
   - Proprietary Catalyst System
   - Renewable H₂
   - 340-470°C
   - <500 psig
3) Fixed Bed
   - Proprietary Catalyst System
   - Renewable H₂
   - <500 psig
4) SMR
   - C₁⁻C₃ Gas
   - HDO'd Vapors

**Products**
- Biogenic CO₂
- Hi Pressure Steam
- Distilled Hydrocarbon
- Clean Water
- Fertilizer
- BioChar
- Gasoline, Jet and Diesel
- Hydrocarbons (67-172 gal/ton)
  - R100 Regular Gasoline (Wood)
  - R100 Intermediate Gasoline (Wood)
  - R60 + Diesel (Wood)

Gasoline, Jet and Diesel
Hydrocarbons (67-172 gal/ton)
R100 Regular Gasoline (Wood)
R100 Intermediate Gasoline (Wood)
R60 + Diesel (Wood)
Demonstrate over Multiple Scales (>10^7)

- >220000L/day Commercial FEL-2
- 2200L/day Showcase
- 22L/day Chicago
- 1L/day Chicago, Bangalore
- 0.02L/day Bangalore
Be Economic vs. Fossil Fuels (NREL Study)

Installed Equipment Costs $127.5mln
- Feed
- 1st Stage/2nd Stage
- Fractionation
- HMU
- Ammonium Sulfate
- Absorption/Stripping
- Utilities & Contingency @ 35%

Operating Costs Total $1.64/gal*
- Wood $71.97/dry ton
- Other Op Costs: Catalyst, Disposal, etc.
- Fixed Cost
- Depreciation
- Avg Income Tax
- Avg ROI

Total Capital Investment $263mln
- Installed Equipment Costs
- Land/Develop
- Permits & S/U
- Standard Project Add-In’s**

- Stand Alone/Green Field (US Gulf Coast basis)
- 2000mt/d wood (50% moisture fed, dried to 10% moisture at 1st stage)
- Conservative: 60.9 vs 66.4mln gal/year; 4500bbl/day
- Equipment cost - HMU is largest @ $55mln ~45% TIC
- Feed Stock ~55% of Operating Cost
- No subsidies, tax, RIN or carbon credits included! $3.96capex/annual gal
- Minimum Fuel Selling Price – $0.433/L (2007) $0.476/L (2012)
- $1.64/gal $1.80/gal
- Refinery Synergy w/Refinery H2 Supply
  - Estimated MFSP $0.359/L (2007) $0.394/L (2012)
  - $1.36/gal $1.49/gal
- KBR FEED underway (FEL-2 complete)
- Opex validated by prospective clients

** Prorated Expense (10%), H O & Construction (20%), Field Expense (10%), Working Capital (10%), Project Contingency (30%)


8/2/2013
Know and Engage Key Stakeholders

- Potential customers include biomass and energy companies
- Local, State and National governments (Thank you US DOE!)
- Fuel qualification/certification/registration
- EPC companies
- Technology suppliers
- Off take agreements
- Funding entities
- Sustainability groups
- Consumers…
Partner Early

• Develop individual CVPs, the larger the prize the better
• Understand client specific drivers same
• Understand client risk appetite
  – commercial risks largely mitigated with fungible fuels
  – some technical uncertainty remains
  – mitigate operational risk
• Share risks where possible
• Phased project approach
• Long term mutual commitment to success
Thank You

Learn more at www.cricatalyst.com/catalysts/renewables.html