Prospects for the Commercialization of Cellulosic Ethanol from Forest Biomass

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Range Fuels, Inc.
Range Fuels Overview

- Formed in July 2006 by Khosla Ventures to commercialize cellulosic ethanol
  - Multi-sourced technology

- Supported by substantive federal, state and local incentives
  - DOE: $76MM in a competitive evaluation
  - Other state and local incentives

- Development Center and K2A Pilot Plant complete

- Broke ground in Soperton, GA, for first U.S. commercial-scale cellulosic ethanol plant utilizing woody biomass

- Additional sites and partnerships secured
Increasing Ethanol Demand and Support

- 60% growth in demand from 4 Bn GPY in 2005 to 6.6 Bn GPY in 2007
- Strong, bipartisan support for cellulosic biofuels
  - Recent passage of “Energy Independence and Security Act of 2007”
  - 36 Bn GPY by 2022 includes 21 Bn GPY of Advanced Biofuels
  - Increased cellulosic credits likely in new Farm Bill in 2008 ($0.64/gal)

Higher demand for E85 fuel as FFVs are more widely adopted
- By 2012 U.S. automakers have committed to% of production to FFVs

Source: Renewable Fuels Association
U.S. Cellulosic Ethanol Potential

- 140 Bn GPY – 2005 U.S. DOE/USDA Study
  - Agricultural 100 Bn gpy
    - Crop residues, perennial crops, animal manure, process residues and grains used for biofuels
  - Forestlands 40 Bn gpy
    - Wood and paper & pulp processing residues, logging and site clearing residues, fuel treatment thinnings

- Total U.S. Gasoline Consumption
  - 140 Bn gpy
  - President’s goal - 35 Bn gpy alternative fuels by 2017
Worldwide Cellulosic Ethanol Potential

- Total Worldwide Gasoline Consumption
  - 300 Bn gpy vs. 140 Bn gpy from U.S.

- Assessments Underway Globally
Range Fuels’ Business

- Focus
  - Green energy
  - Cellulosic ethanol

- Business Model
  - Design
  - Build
  - Own
  - Operate

- Global Presence
Key Highlights

- Thermo-chemical based technology with a developmental headstart
  - Economically competitive without subsidies from inception

- Low marginal cost of production

- Feedstock flexibility
  - Feedstock advantages of woody biomass

- Highly scalable business model; replicable plant modules

- Environmentally friendly production process

- Access to economic development funds and additional legislative measures that support development of cellulosic ethanol technologies

- Experienced management team and strategic investors and partners
Operational Facilities

- 4 generations of biomass conversion testing environments
- Catalyst testing facilities
  - CC10’s
  - CC100
- Pilot-scale
  - CC400
  - CC1000

K2A Optimization Plant
Management Team

  - Mitch Mandich, CEO – Apple Computer
  - Rick Winsor, President & COO – Horizon Wind Energy
  - Kevin Biehle, V.P. Production – VeraSun; BASF
  - Mike Cate, V.P. Procurement & Fabrication – Washington Group
  - Arie Geertsema, Sr. V.P. Technology – CAER; Sasol
  - Dan Hannon, CFO – Reliant Energy, Exxon
  - Bud Klepper, Chief Technical Specialist – Inventor
  - Larry Robinson, V.P. Projects - Bechtel
  - Bill Schafer, Sr. V.P. Business Development – NexGen
Limitations of Current Technology

- Current production technologies use corn or sugarcane
  - Limited max. capacity (corn 15 BGY); high cost
  - Import tax of $0.54/gallon

- Food versus fuel
  - Low land efficiency for fuel production
  - Sharp increase in feedstock prices
  - Depleting water tables
  - Wide price fluctuations due to weather
  - Resistance from animal feed lobby

- Low fossil energy ratios
  - Corn at 1 to 1.4 input to output
  - Sugarcane ethanol at 1 to 8
  - Cellulosic ethanol at 1 to 10

Corn Prices

$ / Bushel

Source: Bloomberg
Range Fuels’ Technology

- Cheaper than gasoline, unsubsidized
- Cheaper, less volatile feedstock
- Flexible “high volume” feedstock supply
  - Wood chips
  - Municipal waste
  - Industrial waste
  - Manure
  - Switchgrass
  - Corn stover
  - Olive pits
  - Coal
- Environmentally superior

Sources: Bloomberg and Pöyry
Differentiated Technology

- Proven two-step thermo-chemical process
- Highest yield of ethanol per ton of feedstock

**K2 System Configuration**

```
Feedstock Storage → Feedstock Handling → Biomass Converter
  |               |                 |
  | Step 1       | Step 2          |
  | Devolatilization | Catalytic Converter |
  | Reforming     | Syngas          |
  | Conditioning  |                |
  |               | Catalysis       |
  |               | Distillation / Fractionation |
  |               | “Self-Sustaining” Tailgas |
```

Product Storage

Process Time <30 min

Ethanol & Methanol

Shipment to Market
Environmentally Friendly Production Process

- Soperton: minor emissions source permit
  - Only one waste stream: saleable char

- Lower water use
  - 25% of typical corn-ethanol plant
  - Reduces purification costs and impact

- Material land use benefits
  - Polyculture “compatible”
  - Better yields, biodiversity, low inputs
World’s First Commercial Cellulosic Plant
Soperton, GA: World’s First Commercial Cellulosic Plant

1. **Wetlands:**
   Will be protected and left undisturbed

2. **Range Fuels Drive:**
   Specially created road that separates plant operations from the wetlands

3. **Feedstock Receiving and Storage:**
   Receipt and storage of wood chips

4. **Conveyor System:**
   Moves feedstock from receiving and storage area to modular converters

5. **Biomass Converters:**
   Convert wood chips to syngas

6. **Catalytic Converters:**
   Transform the syngas into alcohols, which are then separated and processed

7. **Product Storage:**
   Collection and storage of liquids (ethanol and methanol)

8. **Loading and Delivery:**
   Transportation by either truck or rail
Soperton Plant – Site Work
Soperton Plant – Artist’s Rendering
Soperton Plant – Groundbreaking
Soperton Plant – Groundbreaking
Soperton Plant – Site Clearing
Soperton Plant – Woody Biomass Feedstock
Stable Pricing, Large Availability Using Woody Biomass

- Over 400 MM tons of “low cost” woody biomass available annually
- High land efficiency for cellulosic crops; low water and fertilizer inputs
- Cellulosic availability fits demand; fewer transportation issues
- Little competition for feedstock as paper mills decline

U.S. Ethanol Biorefinery Locations

- Biorefineries in Production
- Corn-Ethanol Production
- Biorefineries under Construction
- Major Gasoline Consumption

Non-Federal Forest Land Density, 1997

- 25,000 acres of Forest Land per dot
- 95% or more Federal area

Source: Renewable Fuels Association
Source: U.S. Department of Agriculture
Why Georgia?

- “In the southeastern U.S., trees are agriculture. In the western U.S., they’re parks”
- Sustainability is key!
  - Plants cannot be economically relocated
    - Woody biomass must be sustainably and economically available with a proven silviculture, harvesting and transportation infrastructure
    - Competing biomes
      - Growing season
      - Rainfall
      - Soils
    - Competing tree farmers or state and federal agencies?

- Renewable Biomass is:
  - **Planted trees and tree residue from actively managed tree plantations on non-federal land cleared at any time prior to enactment of this sentence.**
    - Does this include "commercial thinnings"?
    - How is "actively managed" defined?
    - If it has been cleared at any time in the past is it eligible? Is forestland cleared 100 years ago eligible, or is that not considered actively managed?
  - **Slash and pre-commercial thinnings that are from non-federal forestlands.**
    - How are slash and pre-commercial thinnings defined?
    - Non-federal forestland exclusion will discourage any siting in regions dominated by federally managed forestlands, i.e. the western U.S.
We need a package that competes with other options

- **Economically**
  - Delivered cost of woody biomass
  - Cost of infrastructure and operations
    - Tax rates
    - Power and natgas rates
    - Labor rates
    - Rail and truck access for feedstock deliveries and product shipments
  - Value of cellulosic ethanol

- **Environmentally**
  - Impact of plant operations
    - Rural communities
  - Impact of feedstock growing, harvesting and transportation operations