Feasibility Study
Bois Forte Multisource Cellulosic Biofuel Demonstration Project

Presented by Mark Broses (SEH) on August 28, 2007
Outline

• Project Goal
• Project Overview
• Background
• Feasibility Study Framework
• Economic Topics
• Engineering Topics
• Environmental Topics
• Social and Community Topics
Project Goal:

- Produce a renewable and sustainable energy source
- Increase employment opportunities for members of Nett Lake Reservation
- Make more efficient use of resources of the Bois Forte Reservation and surrounding area
Project Overview

• Project comprised of three phases:
  – Scoping Report (January – February 2007)
  – Technical and Feasibility Study (July 2007 – April 2008)
Scoping Report (completed)

- Determined specific engineering, environmental, economic and social factors to be addressed in the Technical and Feasibility Study
Technical and Feasibility Study

• Study and analysis of:
  – Biomass waste streams
  – Costs and operational constraints of specific technologies
  – Permitting and environmental parameters
  – Financial and business plan
Demonstration Project Development

- Design, permitting, site preparation and construction of a demonstration-scale facility

Dynamotive bio-oil facility
Background
What is Cellulose?

• The alternative feedstock to corn for ethanol production is low-cost lignocellulosic biomass (LCB)

• Laboratory studies show ethanol from LCB is more energy efficient than from corn

• Examples of LCB:
  – Crop residue
  – Perennial grasses and shrubs
  – Logging residue
  – Other woody biomass
Local Feedstock

Local sources of woody biomass:
- Logging operations (residual material, slash, etc.)
- Road management trimmings
- Brush harvesting
- Sawdust and woodchips from area sawmills
Local Feedstock, continued

• Other biomass sources:
  Weeds such as cattails harvested from Nett Lake
Woody Biomass Availability

Maps from study by MN Center for Energy & Environment
Woody Biomass Availability

Maps from study by MN Center for Energy & Environment
Woody Biomass Availability
Biofuel from cellulose

• There are two types of technologies to convert biomass to fuel
  – Biochemical process: Enzymatic fermentation
  – Thermochemical process: Gasification, pyrolysis
Biochemical Process

• Similar to current corn ethanol production
• Biomass is pretreated to break down plant cell walls
• It is then broken down into sugars through enzymatic hydrolysis
• These sugars are fermented to form ethanol
• Current research is focused on improving enzyme performance while reducing its cost
Biochemical Process

http://www.verenium.com/Pages/Biofuels/BiofuelsCellulosicEtoh.html
Thermochemical Process

• Usually a two step process

• First, synthetic gas, made up of carbon monoxide and hydrogen, is produced through gasification or pyrolysis of the biomass

• Second, the syngas is converted either through a catalytic reaction or by bacteria into various products such as ethanol or butanol

• Process is very flexible towards different biomass sources and can produce a variety of products
Pyrolysis

Biomass Liquefaction via Pyrolysis

Biomass $\rightarrow$ PYROLYSIS $\rightarrow$ Vapors $\rightarrow$ CONDENSATION $\rightarrow$ Liquids $\rightarrow$ Power Generation or Chemical Separation

PYROLYSIS
550°C no $\text{O}_2$

Vapors

Char

Heat

Combustion

Gases
($\text{H}_2, \text{CO}, \text{CH}_4, \text{C}_2\text{H}_2, \text{C}_2\text{H}_4$)

Catalytic Conversion to Hydrogen (Optional)

http://www1.eere.energy.gov/biomass/pyrolysis.html
Gasification

http://www1.eere.energy.gov/biomass/large_scale_gasification.html
Strategic Benefits of Project

- Sustainable and diverse economic growth of the Bois Forte Reservation through new jobs and long term career opportunities
- Economic diversification of energy resources in Northern MN
- Reduction of energy cost of tribal operations and facility maintenance to promote community independence
- Carbon capture and greenhouse gas reduction
- Reduce reliance on imported oil to increase local and national energy security
Six-step Study Approach

1. Understand role of ethanol production in MN
2. Identify alternative possibilities for biofuel production on Bois Forte Reservation
3. Analyze environmental, economic and social impacts of alternatives
4. Compare the technical alternatives
5. Prepare an economic feasibility analysis of technologies and feedstock combinations to make site-system-feedstock profitability estimates
6. Develop recommendations
Economic Topics
State of the Current Energy Industry

- Average production of corn ethanol plants: 10-40 million gallons per year
- The Band is considering a 1-4 million gallon/year facility based on preliminary estimates of available feedstock
- The National Renewable Energy Laboratory (NREL) has cited larger facilities as more efficient, but smaller facilities as having lower transportation costs
- The feasibility study will address optimal sizing for the facility
Key Economic Issues of Project

- What scale of facility is operational for the Band?
- What types of new jobs would be created? How many?
- Which market segments would products be sold to?
- How are the geographic distribution, ownership, technology and size of biofuel facilities changing in Minnesota and why?
- Who makes decisions over raw material harvest and handling practices?
Economic Factors to Compare

• Capital costs of chosen technology and facility improvements
• Operating costs of chosen technology
• Percentage of debt incurred for facility
• Interest rates of loans taken on facility
• Electrical, natural gas or propane prices
• Federal, state or local production subsidies or incentives
• Cash flow and debt repayment of facility
Engineering Topics
Procurement of Feedstock

- Evaluate and compare between technologies:
  - Feedstock supply, cost and long term availability
- Low cost residual material is preferred
- Steady stream of sustainable feedstock is necessary for efficient operation
Logistics of Feedstock

• Collection, handling and processing operations will be developed

• Feedstock will need to be cut to size and separated from waste material
  – May happen at harvest site or at the facility

• Additional labor and equipment are necessary for this step, creating new job opportunities
End Markets

• Compare profits from end markets

• Examples:
  – Ethanol as gasoline additive
  – Sale of co-products such as acetone, butanol, dimethylether
  – Steam and electricity for Band use and/or sale to the transmission grid
  – Bio-Oil and syngas could be used to heat the local school and houses
Institutional Incentives and Challenges

• Renewable energy is a valuable but new technology
• Financial and technical support will be needed
• State and Federal regulations recognize this, are promoting renewable energy projects
Cellulosic Biofuel Technologies

The Scoping Report identified companies to investigate:

- Biochemical systems:
  - Iogen
  - Mascoma
  - Verenium

- Thermochemical systems:
  - BRI
  - Range Fuels – Khosla Ventures

The Feasibility Study will also examine new companies including:

- Dynamotive
- ChipTec
- Community Power
Iogen

• Uses enzymatic hydrolysis technology to produce ethanol from biomass

• Built and operates a demonstration scale facility located in Ottawa, Ontario Canada
• Developing bio and process technology for cost-effective enzymatic conversion of cellulosic biomass

• Has funding to build and operate a biomass-to-ethanol demonstration plants in Rochester, New York and in Michigan

• Consortium support of project includes Cornell University, Clarkson University, International Paper Co., Natural Resource Defense Council and Genencor.
• Celunol and Diversa recently merged to form Verenium, combined cellulosic ethanol technology with advanced enzyme research

• Recently expanded their 50,000 gal. cellulosic ethanol pilot plant to a 1.4 million gal. demonstration plant in Jennings, LA.

• Full-scale demonstration plant built in Osaka, Japan under sublicense
BRI

• Uses a two-stage process
  – decomposes carbon material into synthetic gas (syngas) through a thermal gasification step
  – Patented bacterial culture reconstructs the syngas into ethanol and water in less than two minutes

• Waste heat from process used to power the plant

• Each module capable of processing 125-150 tons of biomass/day
Range Fuels – Khosla Ventures

- Produces ethanol, butanol and/or dimethyl ether from a wide range of marginal biomass
- Two step thermochemical conversion technology – known as K2- eliminates use of expensive enzymes
- Recently received a construction permit to build a commercial scale cellulosic ethanol plant in Georgia

www.rangefuels.com/home
• Uses a pyrolysis process to produce bio-oil from wood waste

• Bio-oil is a competitive replacement for No. 2 and No. 6 heating oils and can be converted into other valuable fuels and chemicals

• Built and operates a bio-oil plant in West Lorne, Ontario that processes 130 metric tons/day of sawdust waste

• Completing construction on a plant in Guelph, Ontario that will have a 200 ton/day capacity
“Close Coupled” technology involves two chambers
- First chamber is a 1400°F gasifier that produces pyrolysis gas
- The gas is then oxidized to produce electricity in a 2300°F boiler chamber

Chiptec sells equipment ranging from 12 to 1500 HP boiler capabilities, largest system consumes approx. 5 tons biomass/hr

Over 50 systems have been sold and are operational for community facilities such as schools and hospitals.
• Community Power’s Biomax gasification systems are self-contained and produce either syngas (to replace propane) or electricity for use at schools, hospitals, and other community facilities.

• They sell 5 to 50 kW modules.

• Biomax systems can process a variety of biomass feedstocks, such as wood chips, wood pellets and nut shells.
Primary Products: BioMax 5 to BioMax 50

World’s first, fully automated, environmentally friendly, small modular biopower systems, designed for high volume, low cost manufacture

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*Uses wide variety of woody residues to provide power and heat for:*

- Rural communities (US and foreign)
- Homes (net-metering, prime / back-up)
- Small enterprises (use on-site residues)
- Government facilities

*Stand-alone Gas Generator for:*

- Crop & wood drying (sawmills, wood working)
- Back-up for propane and/or natural gas
- Building heat (workshops, green houses, etc.)
- Cooling/chilling (buildings, food & crop preservation, etc.)
Environmental Topics
Water Resources

• How can biofuel source material storage, handling and transportation protect water resources?

• How can water resources be used responsibly within biofuel production technologies?

• What are best management practices to prevent water contamination?
Air Quality

• How do emissions vary between technology systems?
• What monitoring and mitigation techniques are most effective?
• How much will use of the biofuel products reduce local and national greenhouse gases?
• Which technology promotes the most effective carbon capture?
Soils and Land Use

• How are soil properties affected by biomass cultivation and harvesting, facility construction, and biofuel production?
• Which biomass resource management, facility management, and biomass storage techniques maximize positive and minimize negative effects on land resources?
• What are Tribal policies regarding sustainable land use and conservation?
• How can sustainable practices be used to enhance wildlife habitats
Facility Siting

- Identify and evaluate locations for the facility
- Consider topics such as size, transportation infrastructure, local environmental issues, distance from Nett Lake community
- Identify permitting parameters and agencies
Health and Safety

• What are current regulations and practices related to biofuel production to protect health and safety of the community?

• How should worker safety be protected?
  – Are OSHA standards applicable?
  – If not, should they be modeled?
Facility Permit / Environment Analysis

• Potential Environmental Planning Documents:
  – Water appropriation
  – Environmental Review
  – Air Permit
  – Air Dispersion Modeling
  – Air Emission Risk Assessment
  – Water permits
  – Storage Tanks
  – Hazardous Waste
  – Natural Heritage Info. Request
  – Wetlands Joint Notification
Social and Community Topics
Social Elements

• What is the relation between various biofuel production technologies and:
  – Community and institutional factors
  – Demographics
  – Community values
  – Individual and family changes
  – Community resources (workforce and training)
  – Increase opportunities and responsibilities
  – Developing relationships/partnerships with other tribe organizations
  – Increased interaction and promotion of goodwill in local community, County, and State
Conclusion

• This project could greatly benefit the Bois Forte Tribe by:
  – Increasing job and long term career opportunities for members of Bois Forte Reservation
  – Making productive use of resources of the Bois Forte Reservation and northeast Minnesota
  – Producing a renewable and sustainable energy source for future generations
Thank You

Questions?