Technology/Business Opportunities for the Forest Products Industry

Forest Products Techno-Business Forum
Tuesday October 26, 2004

Paul Grabowski
U.S. Department of Energy
Office of Biomass Program
Program Goals

Develop biorefinery-related technologies to the point that they are cost and performance competitive and are used by the nation’s transportation, energy, chemical, and power industries to meet their market objectives.

Intermediate Targets

- **Syngas** - from $6.14/GJ (2003 base case cost estimate) to $5.01/GJ by 2010.
- **Sugar Feedstocks** - from $0.14/lb (2003 base case cost estimate) to $0.10/lb by 2012.
- Industrial viability of three commodity scale products by 2010.
- $35 per dry ton for biomass feedstock 2010.

2005: Demonstrate an integrated process for fuels production from biomass

2007: Complete technology development necessary to enable start-up demonstration of a biorefinery producing fuels, chemicals, and power

2010: Help U.S. industry to establish the first large-scale biorefinery based on agricultural residues
Program R&D Focus

Biomass

Thermochemical Platform (Gasification, Pyrolysis)
- Combined Heat & Power
- CO, H2, Bio-oil

Sugar Platform (Hydrolysis)
- Sugars, Lignin

Residues
- By-products

Fuels, Chemicals & Materials

Sugars, Lignin
Combine Platform R&D into an Integrated Biorefinery

**Starch**
- Starch Hydrolysis
- Fermentable Sugars
- Cellulose Hydrolysis
- Pre-treatment

**Lignocellulosic Biomass**
- Thermo-chemical Conversion
- Lignin Residue

**Fermentation of Sugars**
- Glucose
- C5/C6 Sugars
- C5 Sugar(s)

**Products**
- Food Products
- Animal Feed

**Product Recovery**
- Ethanol
- Chemicals

**Additional Products**
- Heat & Power
- Fuels & Chemicals
  - Pyrolysis Oil
  - Syn Gas
Forest Biorefinery (FBR) Evolving Concept

- Extract portion of the hemicellulose
- Convert the extract to ethanol and chemicals
- Cellulose still used to manufacture paper
- Liquid Fuels and Chemicals from:
  - BL Gasifier, and
  - Wood Residual Gasifier
- Black Liquor & Residuals
- Steam, Power & Chemicals
- Pulp Manufacturing
Potential Elements of a “Pre-Digester” System for FBR

- Pre-treatment
  - Lignocellulosic Biomass
- Cellulose Hydrolysis
- Fermentation of Sugars
  - C5/C6 Sugars
  - Lignin Residue
- Thermochemical Conversion
- Ethanol Recovery
  - Ethanol
  - Chemicals
  - Heat & Power
  - Fuels & Chemicals
    - Pyrolysis Oil
    - Syn Gas
Developing the Forest Biorefinery Plan

- Met with key stakeholders in the FP industry, academia, and national laboratories to provide input into the OBP’s R&D technical plan for the forest biorefinery.

- The forest biorefinery plan is organized to fit OBP R&D focus areas:

1. Feedstocks
2. Sugar Platform
3. Thermochemical Platform
4. Products
5. Integrated Biorefineries
Feedstock Interface R&D

- The Program has identified several barriers in feedstock:
  - The de-coupling of feedstock research from the Biomass Program to USDA must be revisited. It’s vital that communications and coordination be maintained.
  - DOE and industry need to be proactive in working with the USDA to investigate the opportunity of the Healthy Forest Restoration Act of 2003 to provide feedstocks to forest biorefineries.
  - Research activities for sustainable forestry need to include hardwood species; e.g., willow, poplar and aspen; in addition to loblolly pine.
  - The potential for generating 2–3 times the current harvest production from forests with better harvesting techniques and management should be examined.
Sugars Platform

- Sugars Platform-related R&D seeks to maximize the conversion of the Pre-Digester hemicellulose component
  - Extract up to 50%
  - Convert up to 80%

- The extracted sugar mixture would subsequently be used to produce fuels and chemicals.

- Preserve the cellulose component for use as pulp and paper.
Sugar Platform R&D Needs

- Cost-benefit analysis on the process cost and value of separating hemicellulose component from wood prior to the pulping process.
  - Similar to the 2003 study performed by Larson et al on black liquor gasification.

- Critical technical barriers are focused on the pretreatment
  - Expected reduce cost of producing sugars from hemicellulose in a forest biorefinery

- Need a cost effective pretreatment step to release hemicellulose sugars and preserve cellulose fibers for higher value uses by the forest biorefinery.
The Thermochemical Platform-related R&D seeks to increase the capability to:

- **Produce low-cost intermediates** (syngas and pyrolysis oils)
- **Produce low-cost on-site electricity and process heat and steam.**
- **Integrate with conversion technologies to produce fuels/chemicals**
  - “Other Peoples Technologies”
- **Develop unique & innovative conversion technologies**
Thermochemical R&D Needs

- Identify a short list of “top” fuels and or chemical from syngas in FBR - then, develop a critical pathway.
- Rigorous analysis of the two gasification options.
- Thermochemical processing chemistry requires additional investigation to support the commercial demonstration program and facilitate the development and scale-up of advanced gasifiers and gas clean-up systems.
- Available clean-up technologies do not meet cost, performance, or environmental criteria.
- Develop new sensors, analytical instruments, and process modeling tools to optimize control systems for thermochemical technologies.
- Develop new product specification and standards, e.g., ASTM standards for pyrolysis oil since significantly different from petroleum-based oils.
- Demonstrate long-term catalyst effectiveness using fixed-bed catalysts in the presence of inorganic particulates for wet gasification.
- Long-term, economically acceptable integrated approaches need to be developed for BLG systems both in low and high-temperature reactors.
Products Platform

- Biopower, biofuels, and bioproducts are all included in the OBP’s R&D portfolio.
  - The production of these biobased products will also contribute to meeting the technical goals of the Sugar and Thermochemical Platforms.
  - Comparable to a petroleum or petrochemical refinery

- OBP will identify desirable products that can be produced from all components of biomass in a forest biorefinery.
  - Specific products and relative amounts of the products will vary widely.
  - Specific products for specific markets requires industrial partners with a very clear understanding of the performance attributes and dynamics of the market.

- Products R&D will optimize consumption of the biomass feedstocks in an integrated forest biorefinery in order to create additional economic value.
Products R&D Needs

- Different technical barriers exist depending on whether the fuel, chemical and power products will be produced from the outputs of the Sugars Platform or the Thermochemical Platform.

- Many possible end-products can be made from the outputs of these two platforms,
  - *some having greater energy or economic impact potential than others.*
Products R&D Needs

For products in FBR from:

✓ Sugar Platform
  - improved biological catalysts to convert sugars to building block intermediates
  - improved chemical catalysts to convert sugars to building block intermediates
  - improved fundamental understanding of chemical reactions to products.

✓ Thermochemical Platform
  - cleanup technologies do not meet cost, performance or environmental criteria.
  - ensure that appropriate conversion technologies are available for producing chemicals and fuels from syngas.

✓ General Products
  - cost effective separations to recover and purify products from biomass.
FBR Integration

- OBP is taking a systems integration approach
  - *Translate the technical successes from its other core R&D areas into a fully-integrated forest biorefinery.*

- Make improvements to existing technologies and applying them to existing biorefineries
  - *In tandem with developing and introducing emerging technology*
  - *Accelerate the testing of key technology components for emerging biorefineries in existing commercial operations.*
FBR Integration R&D Needs

- Control multiple product streams.
- Hot gas cleaning and turbine design and integration
- Understand how extraction of hemicellulose affects pulping.
- Cost-benefit analysis on the value of separating hemicellulose component from wood prior to pulping
FBR-Related Budget

- FY06-FY10 funds will be requested to support the FBR technology development plan.
  - FY06-increase FY05 budget by $10M to support Products portfolio and a new solicitation for R&D related to forest biorefinery.
  - FY07-FY08-Request additional $10M/year to support core R&D and industrial partnership for the FBR
  - FY08-Biorefinery Solicitation ($40M) with major industry partner collaboration
FY05 Solicitations

- **Products**-
  - Any work related to the biological conversions, chemical conversions or separations, for the production of building blocks or value added chemicals, and fuels.
    - Research to Develop Chemical Building Blocks
    - University Research in Biomass Technologies

- **USDA/DOE Joint Solicitation**
For more information...

- Visit the OBP’s Web site at www.eere.energy.gov/biomass
  - **Financial Opportunities**
    - Program Solicitations
    - USDA/DOE Joint Biomass Initiative Solicitations
  - **Multi-year technical plan/Current R&D**
For more information...

BACK UP SLIDES
An integrated biorefinery makes use of:

- **Thermochemical conversion technology**
- **Biochemical conversion technology**
- **Existing technology**

**OBP Biorefinery Vision**

- Feedstock Handling
- Pretreatment
- Gasification/Pyrolysis
- Enzymatic Hydrolysis of Cellulose
- Multi-sugar Fermentation
- Ethanol Recovery
- Fermentation for Bioproducts

**Lignocellulosic Biomass**

- Hydrogen/Pyrolysis
- Gas Conditioning & Separation
- Synthesis
- Steam and Power Generation

**Products**

- Lignin Products
- Sugar Intermediates
- Sugar Intermediates
- Lignin
- Fuel Ethanol
- Bioproducts
- Electricity Coproduct
- Fuel
- Lignin Residue