U.S. Department of Energy
Energy Efficiency and Renewable Energy
Office of the Biomass Program

U.S. Department of Energy’s
Involvement with Gasification

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National Energy Technology Laboratory

Colloquium on Black Liquor Combustion and Gasification
Park City, Utah
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Presidential Initiative:
Focused on Results

- Drivers for Organization Change
  - Strategic Program Review
    - Focus on programs and program management
  - President’s Management Agenda
    - Flatten organization to make them more responsive
    - Focus on results, not process
    - Link budget with performance
    - End overlapping functions, inefficiencies, and turf battles
    - Make the most of our people, their knowledge, skills, and abilities
Energy Efficiency and Renewable Energy Guiding Principles

- Dramatically reduce or even end dependence on foreign oil
- Increase viability and deployment of renewable energy
- Increase reliability and efficiency of electricity generation, delivery and use
- Reduce the energy intensity of industry
- Create the new domestic bioindustry
- Lead by example through government’s own actions
- Change the way that EERE does business

A New Streamlined, Integrated, and Focused Model
Office of Biomass Programs

Mission
- To foster research and development on advanced technologies to transform our abundant biomass resources into clean, affordable, and domestically-produced biofuels, biopower, and high-value bioproducts for improving the economic development and enhancing the energy supply options of the U.S.

Goals
- Reduce U.S. dependence upon foreign sources of petroleum
- Realization of the Industrial Biorefinery

OBP Program Areas

Advanced Biomass R&D
- Biochemical R&D, Products Development
- Feedstock, SBIR/STTR
- Pretreatment, Biodiesel
- Products Development

Systems Integration & Production
- Gasification Demos F&PP
- Gasification Systems R&D, Modular Systems/Digestion
- Ag Integration
- Biodiesel Validation and Testing
- Biorefinery Solicitation
- Feedstock Infrastructure
Foreign Oil Displacement

- U.S. transportation sector is almost completely dependent on petroleum. Over half of the oil used in the U.S. is imported from abroad.
- Need to encourage use of alternative biobased fuels
  - Ethanol and biodiesel fuels
  - Gasoline production from synthesis gas
  - Hydrogen production from synthesis gas as a fuel for fuel cells

Black Liquor Gasification: Importance to Program Goals

- Pulp Biorefinery Today (Kraft Mill)
  - Purchased Energy
  - Paper Products
- Pulp Biorefinery of the Future
  - Purchased Energy
  - Paper Products
  - Electricity
  - Chemical Derivatives from Lignin and Syngas
The New Industrial Biorefinery

Biomass Feedstock
- Trees
- Grasses
- Agricultural Crops
- Agricultural Residues
- Animal Wastes
- Municipal Solid Waste

Conversion Processes
- Enzymatic Fermentation
- Gas/liquid Fermentation
- Acid Hydrolysis/Fermentation
- Gasification
- Combustion
- Co-firing

Example Uses
- Fuels: Ethanol, Renewable Diesel
- Power: Electricity, Heat
- Chemicals: Plastics, Solvents, Chemical Intermediates, Phenolics, Adhesives, Furfural, Fatty acids, Acetic Acid, Carbon black, Paints, Dyes, Pigments, and Ink, Detergents
- Food and Feed

Support Realization of the Industrial Refinery

- A biorefinery processes primary and secondary biomass into valued added product streams.
- Biorefineries are based on a number of processing platforms using mechanical, thermal, chemical and biochemical processes.
Building a worldwide Biomass-Based Industry calls for vigorous action on three fronts:

- Scientific and technological innovation across multiple disciplines to maximize the potential of biomass;
- Private investment in markets and infrastructure to lay the foundation for a substantial new U.S. biobased products and biomass energy industry; and,
- Development of supportive government policies that accelerate technological and market development.

Black Liquor Gasification

- **Outcome:** to transform 160 U.S. pulp and paper mills into energy exporting **Biorefineries**
- **Objectives:** to demonstrate
  - the energy, environmental, and safety benefits of black liquor gasification (BLG)
  - the technical performance, operating reliability, and cost-effectiveness of **commercial-scale** BLG systems that are **integrated** into an operating pulp mill environment
- Program working to resolve technology gaps through research and technology demonstrations.
Two-pronged Approach

Wide-spread Commercialization of BLG

Black Liquor Gasification Program Structure

U.S. DOE
Office of the Biomass Program

Project Management
National Energy Technology Laboratory

Technology Demonstrations
- Georgia-Pacific
- GTI/Boise Cascade

Technology Support Projects
- University of Utah
- Nat’l Energy Technology Lab (3)
- Sandia Nat’l Lab
- Argonne Nat’l Lab
- Georgia Institute of Technology
- University of Missouri-Rolla
- Oak Ridge Nat’l Lab (3)
- University of Maine
Demonstration Projects

Black Liquor Gasification at Big Island, VA
Georgia-Pacific, StoneChem

Advanced Gasification-Based Fuel Conversion and Electrical Production System at DeRidder, LA
GTI, Boise

Georgia-Pacific – Big Island, VA

- Main participants: Georgia-Pacific, Fluor-Daniel, StoneChem
- Scope: 200 tpd sodium carbonate BLG gasification using pulsed steam reformer to produce steam and (ultimately) power
- Start: 2/13/01
  Finish: 3/30/07
- DOE Budget ($ millions):
  FY01: 22.5
  FY02: 10.1
  FY03: 8.2
- Accomplishments:
  - Design/engineering/purchasing 95% complete
  - Construction 60% complete overall
GTI/Boise Cascade – DeRidder, LA

- **Main participants:** Gas Technology Inst., Boise, DB Riley, Nexant, Carbona, UNDEERC
- **Scope:** low pressure 185tpd (wet) wood waste and sludge gasifier integrated with existing stoker boiler to generate steam and power
- **Start:** 8/8/01  
  **Finish:** 6/30/07
- **DOE Budget ($ millions):**  
  - FY01: 1.0  
  - FY02: -0-  
  - FY03: 0.2
- **Accomplishments:**  
  - Gasification island and stoker-boiler air heater designs are complete
  - Another turbine provider is being sought

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Technology Support Projects  
-- Scope --

- To conduct cost-shared applied research awarded through competitive solicitations that address the technology gaps associated with BBLG
- Manage and coordinate research with a *programmatic* approach
Planned Objective/Outcome of Technology Support Projects

- **Objective:** to resolve specific, well-defined technology gaps that have been identified by experts in the field

- **Outcome:** to make the technology demonstrations successful and robust so that they can be **commercially replicated** in other pulp mills and biopower applications

Five Technical Gap Areas Identified by Industry

- Fuels Chemistry and Reactor Kinetics
- Containment (Materials)
- Mill Integration (steam, power, pulping, and causticizing)
- Process Control and Optimization
- Assurance and Education
Support Projects Currently Address Three Technology Gap Areas

<table>
<thead>
<tr>
<th>Research Area</th>
<th>Technology Gaps</th>
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<tbody>
<tr>
<td>Fuels Chemistry and Reactor</td>
<td>• formation and destruction of tars and their impacts</td>
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<tr>
<td>Optimization</td>
<td>• optimizing carbon conversion without bed agglomeration</td>
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<td></td>
<td>• managing contaminants in the product gas</td>
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<td></td>
<td>• modeling for use in reactor design and process control</td>
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<tr>
<td>Containment/</td>
<td>• metals used for reactor shells</td>
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<tr>
<td>Gasifier Materials</td>
<td>• refractory materials</td>
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<td></td>
<td>• reactor designs that provide acceptable operating up-time</td>
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<td></td>
<td>• modeling internal reactions and circulation</td>
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<tr>
<td>Mill Integration</td>
<td>• minimizing or eliminating the causticizing load increase</td>
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<td>• sulfur recovery</td>
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<td>• hot gas cleanup</td>
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<td>• integration with innovative pulping processes</td>
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<td>• emissions control</td>
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<td>• turbine design and integration</td>
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**Fuels Chemistry and Reactor Optimization Projects**

- CFD Modeling of Boise Biomass Gasifier, Argonne National Laboratory
- Investigation of Fuel Chemistry and Bed Performance in a Steam Reformer, Univ. of Utah
- Chemical Kinetics Analysis of Black Liquor Steam Reforming, NETL
- Modeling of the G-P Big Island Gasifier, NETL
- Optimization of High-Temp Black Liquor Gasifiers, Sandia National Laboratory
- Catalysts for the Destruction of Tars, Georgia Institute of Technology
**Containment/Gasifier Materials Projects**

- Refractory for Black Liquor Gasifiers, *University of Missouri-Rolla*
- Pulsed Black Liquor Reformer Materials Evaluation, *ORNL*
- Materials Evaluation for Black Liquor and Biomass Gasifiers, *ORNL*
- Refractory Structural Materials for Black Liquor Gasification, *ORNL*
- Ceramic Coatings for Use in High Temp., High Pressure Black Liquor Gasifiers, *ORNL*
- Chromium-Rich Alloys for Gasifier and Kraft Recovery Boilers, *ORNL*

**Mill Integration Projects**

- Direct Causticization for Black Liquor Gasifiers, *University of Maine*
- Causticizing for Black Liquor Gasifiers, *Institute of Paper Science and Technology*
- Evaluation of RVS-1Sorbent for Removal of Sulfur from Black Liquor Gasification, *NETL*
BLGCC Cost-Benefit Analysis

- **Study Purpose:** to assess the costs and benefits of BLGCC technology at the mill, regional and national levels, including an examination of utility-scale concepts
- **Analytical Team:** key members include Princeton University, Navigant Consulting, Fluor-Daniel, and Nexant
- **Industry/Government Steering Committee:** US Department of Energy, Georgia-Pacific, International Paper, MeadWestvaco, Weyerhaeuser, Southern Companies, and Tennessee Valley Authority
- **Schedule:** a final report is expected to be available by July, 2003

Future of Our Partnership

- Will continue to build on existing industry partnerships
- Program Review recommendations recognize need to “increase industry involvement” in OBP-sponsored research
- OBP using competitive solicitations to help build partnerships and increase industry participation
Applications of CVX Gasifier include:

- 72 plants worldwide
- Tampa Electric Polk Power Plant
- Delaware Clean Power pet-coke
- Kansas El Dorado IGCC
- Italy... 3 refinery plants
- China... 11 fertilizer & chemical
- Bilboa, Spain
- Indonesia Thermal Power
- Sumatra oil recovery

Applications of E-Gas Gasifier include:

- Indiana, Wabash River

Provided by Global Energy, Inc.
KRW Fluidized Bed Gasifier

Applications of KRW Gasifier include:

- Piñon Pine Power Project

Provided by Kellogg Brown & Root

Transport Reactor Flow Diagram

Advantages of Pressurized Transport Reactor

- Excellent Gas-Solids Contact
- Low Mass Transfer Resistance Between Gas and Solids
- Highly Turbulent Atmosphere
- High Coal Throughput
- High Heat Release Rate
- Designed without expansion joints

Provided by Southern Companies
Please visit the new EERE website for information on the Biomass program.

www.eren.doe.gov