The Natural Resources Research Institute

Coleraine Research Laboratory

Richard Kiesel
Manager - NRRI  Coleraine Laboratory
The NRRI Mission

The Natural Resources Research Institute Charter
To foster the economic development of Minnesota’s natural resources in an environmentally sound manner to promote private sector employment

Minnesota State Legislature, 1983

Deliver research solutions to balance our economy, resources and environment for resilient communities
NRRI Focus Statement

NRRI is an applied research organization focused on

1. developing sustainable, natural resource-based industries,
2. informing environmental management and policy
3. supporting business & entrepreneurial opportunities
4. assisting industry and communities in defining and maintaining the social license

to deliver solutions with both

regional focus and global relevance
History

- The Laboratory
  - Previously US Steel Research and Development Center
  - Originally the Oliver Iron Mining Co.

- The site was donated to the University of Minnesota (NRRI) by US Steel in 1986
Coleraine Research Laboratory

- **Engineering** (Currently 9 full time, 1 casual)
  - Comminution
  - Mineral Processing
  - Pyrometallurgy
  - Process Modeling
    - Computational Fluid Dynamic Modeling
    - Concentrator Flowsheet Development / Modeling
  - Hydrometallurgy
  - NRRI - Renewable Energy Center
    - Bio-Energy
    - Liquid Fuels
    - Solar Energy
    - Biomass Gasification

- **Laboratory Technicians**
  (Currently 20)

- **Office / Support** (Currently 4)
Chemical Laboratory Facilities

State of the art analytical equipment

Inductively Coupled Plasma Spectroscopy
Leco Carbon Sulfur
Wet Iron Titration
Mineral Characterization / Geology

- Thin Section Optical Microscopy
- Scanning Electron Microscopy
- Mineral Liberation Analysis

Exploration Geology
Mineral Processing

- Bench to Pilot Scale Facilities

Davis Tube Magnetic Separator
Pyrometallurgy

• Agglomeration
• Induration
• Sintering
NRRI started enhancing capabilities for alternative fuels in 2006
- Expanded biomass characterization beginning in 2008
- Lab and pilot scale biofuel production capabilities, 2008-2009
- DOE supported study to evaluate biofuels for ironmaking, 2008-2010
- Biofuel densification, 2011
- Future developments in Biofuel production for commercial demonstration, 2014
Historical Wood Harvest
(in million cords/year all forms, 70% pulpwood)

- Downturn in the industry and has not recovered to 2005 levels
- Generally agreed upon sustainable harvest level of 5.5 million cords per year
- Harvesting roughly 50% of potential sustainable
- Potential to utilize lower-value species for energy

Courtesy of Bill Berguson
NRRI - Renewable Energy Center

- Bio-Energy
- Liquid Fuels
- Solar Energy
- Biomass Gasification
What is Biofuel?

- Technically refers to a wide range of fuels derived from biomass or other organic matter.

- For purpose of this presentation:
  - Thermally processed biomass resulting in a combustible fuel with similar attributes to sub-bituminous coal (Powder River Basin).

- A mild pyrolysis at temperatures between 230 and 300 °C,
  - Removes free moisture and light weight volatiles.

- Biomass typically loses 20-30% of its mass (dry solid loss, DSL) and only 10% of its heating value.
What is Biofuel?

Raw Feedstock
-3/8" Wood Chips

Torrefied Wood (300° C)

Torrefied Wood (275° C)
Burns similar to coal
   - HHV approximately 10,000 BTU/lb.

Grinds similar to coal
   - Can be utilized with conventional pulverizing and combustion equipment
   - Hardgrove Grindability Index (HGI) ~ 50

Efficient Burning
   - Allows coal fired applications to run with current combustion configuration
   - Can be fired in combination or blended with conventional coal firing

Energy Density
   - Coal plants are often constrained by the volume of fuel that can cycle through various components of the plant. Biofuel has a similar energy density that allows coal plants to operate at closer to their rated capacity.

Significant quantities of biofuel for commercial scale viability testing or demonstration are not readily available
Development Team:
An Xcel Energy - Renewable Development Fund Grant was awarded for approx. $1.9 million by the Minnesota Public Utilities commission, March 11, 2014.

Project Development Team:

CSR is a Minnesota-based, international not-for-profit have a combined experience in excess of 90 years designing, constructing and repairing pressure vessels and mechanical steam linkage systems.

ST is a technology company that is developing pre-treatment and gasification technologies for use in the production of synthesis gas (syngas) from biomass.
Develop and demonstrate technology that results in:

- Real-world production of electricity from biomass resources
- A reduction in greenhouse gas emissions related to power generation
- Utilization of Minnesota-grown biomass resources as a source for biofuel in cost-effective manner
The research associated with this goal will need to:

• Utilize locally-available biomass to produce electricity efficiently
• Allow rural Minnesotans to power agriculture, forest products operations or townships with various biomaterials
• Potentially generate electricity in the urban environment to provide peak-load relief and/or create net-metering microgrids
• Reduce waste-stream biomass and utilize it to create electricity in the urban environment
• Be of significantly higher-efficiency design than preceding technology
• Categorize the emissions associated with generating electricity from biomass
• Develop prototype, test bed systems that can be readily refined, scaled and commercialized
• Generate local jobs in forestry industry
ST has developed a vertical moving bed process for the production of converted biomass using a modification of the torrefaction process used by other developers that results in a material that is more easily densified after production. The process is based on a gravity-fed, dense phase moving bed wherein the biomass is heated directly with hot gas.

Coalition for Sustainable Rail

A modern, high-efficiency steam-electric boiler generator system

- 100 kW system capable of burning raw biomass and processed, solid, liquid or gaseous biofuels.
• Operate with a thermal efficiency greater than 90%;
• Establish operational control using various raw material inputs;
• Measure overall efficiency of the production system;
• Characterize the energy content, combustion and ash profiles of the biofuel products made from various feedstocks;
• Determine emissions profiles while at steady-state operation of both the conversion reactor and boiler-generator system;
• Develop consolidation methods to produce biofuel products for use in the power generation system;
• Produce tonnage quantities for use in the continued power generation campaigns and
• Demonstrate that the new system can be operated cost effectively through modern process automation and control techniques.
Conclusions

Process change requires considerable down-time with a great amount of risk. Effectively evaluating these changes in a laboratory setting is required to reduce costs and minimize the risk. The Coleraine Lab has capabilities to simulating commercial scale operating conditions on both the bench and pilot scale. When used in conjunction with proper laboratory evaluation techniques, they can effectively be used to investigate process changes.

Is This Possible?
Thank You

Natural Resources Research Institute
University of Minnesota Duluth
Driven to Discover