NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Thermochemical Conversion Pilot Plant

A conversion platform that can be used by researchers, industry partners, and stakeholders to test a range of biomass feedstocks and thermochemical conversion processes and technologies.

NREL's Field Test Laboratory Building houses the thermochemical conversion pilot plant.
Photo by Dennis Schroeder, NREL 25485

The state-of-the-art thermochemical conversion pilot plant includes several configurable, complementary unit operations for testing and developing various reactors, filters, catalysts, and other unit operations. NREL engineers and scientists as well as clients can test new processes and feedstocks in a timely, cost-effective, and safe manner to obtain extensive performance data on processes or equipment.

Pilot Plant Resources	
Feed Processing	• Continuous loss-in-weight feeding system that can feed up to 30 kg/hr of pelletized feed • Integrated pellet crusher • Rotary valve pressure isolation.
Gasification	• 8-inch diameter fluidized bed reactor operating up to 750°C and 75 kPa • Second-stage reactor operating up to 950°C for thermal cracking • Electrically-heated system for energy balances • Integrated steam flow rates up to 40 kg/hr • Syngas production rates up to 30 kg/hr.
Pyrolysis	• Entrained flow reactor for pyrolysis that can operate up to 950°C • Typical gas residence times from 0.5 to 2.5 seconds • Electrically-heated system for energy balances • Integrated nitrogen flow rates up to 20 kg/hr • Continuous, measureable collection of liquid pyrolysis products using a dodecane scrubber; includes integrated downstream collection of aerosols resulting in singular outlet stream • Pyrolysis products (liquid) production rate up to 18 kg/hr.
Solids Removal	• Continuous cyclonic solids removal system to remove residual biomass char and ash with collection for mass balance.
Gas Clean-up	• 14-inch diameter full-stream, fluidized bed reformer operating up to 925°C for semi-batch catalytic reforming of residual tar and hydrocarbons • Re-circulating, regenerating reformer system operating at up to 950°C for full-stream continuous tar and hydrocarbon reforming and catalyst regeneration • Continuous, measureable removal of condensable material in the product stream.
Dedicated Analytics	• Molecular Beam Mass Spectrometer for real-time high-temperature process analysis at multiple process conditions and locations • Gas chromatographic system with sulfur and nitrogen speciation for real-time analysis at multiple process locations • Continuous gas analyzers (e.g., nondispersive infrared, thermal conductivity detector, and residual gas analyzer) at multiple locations for process control and optimization.

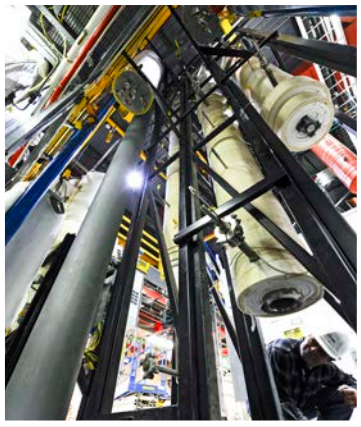
**NREL is a national laboratory of the U.S. Department of Energy,
Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.**

Capabilities and Expertise

- **Flexible system design –** allows for prompt reconfiguration depending on project needs
- **Highly integrated process control system –** ensures stable operation, expeditious mass balance determination, and quality data
- **Skilled operation crews –** provide unique solutions and timely response for equipment repairs and configuration
- **Process control specialist –** provides prompt control system changes as needed for changing operations
- **Feedstock flexibility –** extensive experience feeding a wide range of feedstocks including hardwoods, softwoods, corn stover, corn fiber, distillers dry grains, agricultural waste, and other unique stocks
- **History of collaboration –** research industrial partnerships include Dow Chemical, UOP, Pall, Petrobras, Lanzatech, Taylor Bioenergy and A.E. Staley.

Thermochemical Companion Capabilities

- **Biomass Catalyst Characterization Lab:** For full catalyst analysis www.nrel.gov/biomass/pdfs/51985.pdf
- **Fuel Synthesis Catalyst Lab:** For catalyst screening on bottled and "real" syngas www.nrel.gov/biomass/pdfs/51851.pdf
- **Molecular Beam Mass Spectrometry:** www.nrel.gov/biomass/pdfs/50794.pdf
- **Biomass Compositional Analysis Lab:** For characterization of biomass feedstocks, intermediates, and products www.nrel.gov/biomass/pdfs/51987.pdf.



An NREL engineer inspects the newly installed re-circulating reformer in the thermochemical conversion pilot plant. *Photo by Dennis Schroeder, NREL 25486*

Fully-integrated process control system provides extensive, continuous data throughout thousands of points in the thermochemical conversion pilot plant. *Photo by Dennis Schroeder, NREL 25487*

Associated publications

Dutta, A.; Talmadge, M.; Hensley, J.; Worley, M.; Dudgeon, D.; Barton, D.; Groendijk, P.; Ferrari, D.; Stears, B.; Searcy, E. M.; Wright, C. T.; Hess, J. R. (2011). "Process Design and Economics for Conversion of Lignocellulosic Biomass to Ethanol: Thermochemical Pathway by Indirect Gasification and Mixed Alcohol Synthesis." 187 pp.; NREL Report No. TP-5100-51400.

Carpenter, D. L.; Bain, R. L.; Davis, R. E.; Dutta, A.; Feik, C. J.; Gaston, K. R.; Jablonski, W.; Phillips, S. D.; Nimlos, M. R. (2010). "Pilot-Scale Gasification of Corn Stover, Switchgrass, Wheat Straw, and Wood: 1. Parametric Study and Comparison with Literature." *Industrial & Engineering Chemistry Research* (49): pp 1859-1871.

Jablonski, W.; Gaston, K. R.; Nimlos, M. R.; Carpenter, D. L.; Feik, C. J.; Phillips, S. D. (2009). "Pilot-Scale Gasification of Corn Stover, Switchgrass, Wheat Straw, and Wood: 2. Identification of Global Chemistry Using Multivariate Curve Resolution Techniques." *Industrial & Engineering Chemistry Research* (48): pp 10691-10701.

Bain, R. L.; Dayton, D. C.; Carpenter, D. L.; Czernik, S. R.; Feik, C. J.; French, R. J.; Magrini-Bair, K. A.; Phillips, S. D. (2005). "Evaluation of Catalytic Deactivation during Catalytic Steam Reforming of Biomass-Derived Syngas." *Industrial Engineering Chemistry Research* (44): pp 7945-7956.

For more information, contact:

Esther Wilcox, PhD, 303-384-6516, esther.wilcox@nrel.gov

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

National Renewable Energy Laboratory
15013 Denver West Parkway
Golden, CO 80401
303-275-3000 • www.nrel.gov
NREL prints on paper that contains recycled content

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC

NREL/FS-5100-58532 • June 2013