


A Compelling Case for Integrated Biorefineries (Part III)

A comparison of key projects



The U.S. Department of Energy (DOE) has selected four biorefinery demonstration projects, with three more scheduled for selection. Negotiations with the four following companies have begun in order to determine final project plans and funding levels (subject to appropriations from Congress).

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ICM Inc., Colwich, KS (DOE will provide up to US\$30 million)

The proposed plant will be in St. Joseph, MO, and will utilize diverse and relevant feedstocks including agricultural residues, such as corn fiber, corn stover, switchgrass and sorghum. ICM will integrate biochemical and thermochemical processing and demonstrate energy recycling within the same facility. This project stands to broaden the company's focus from corn-based to energy crop-based ethanol production. ICM Inc. is a privately held company with the mission of sustaining agriculture through innovation, primarily through the engineering and construction of an ethanol biorefinery.

ICM co-participants/investors include: AGCO Engineering; NCAUR-ARS-Peoria; CERES, Inc.; Edenspace Systems Corp.; DOE's National Renewable Energy Laboratory; Novozymes North America, Inc.; South Dakota State University; Sun Ethanol, Inc.; and VeraSun Energy Corp.

Lignol Innovations Inc., Berwyn, PA (DOE will provide up to US\$30 million)

The proposed plant, co-located with a petroleum refinery, will be in Commerce City, CO, and will use biochem-organosolve to convert hardwood

and softwood residues into ethanol and commercial products. Lignol Innovations is a U.S.-based company with a publicly-traded Canadian

parent based in Vancouver, British Columbia. Lignol has acquired and since modified a solvent-based pre-treatment technology that was originally developed by a subsidiary of General Electric.

Lignol Innovations participants/investors include: Suncor Energy and Parker Messana & Associates.

Pacific Ethanol Inc., Sacramento, CA (DOE will provide up to US\$24.3 million)

The proposed plant will be in Boardman, OR, and will convert agricultural and forest product residues to ethanol using BioGasol's proprietary conversion process. Pacific Ethanol is a leading producer of low-carbon renewable fuels in the Western U.S. The company is headquartered in Sacramento and is planning to add cellulosic conversion capability to its corn-based ethanol facility in Oregon.

Pacific Ethanol's investors/participants include: Biogasol LLC and DOE's Joint Bioenergy Institute (DOE's Lawrence Berkeley National Laboratory and Sandia National Laboratories).

NewPage, Wisconsin Rapids, WI (DOE will provide up to US\$30 million)

The proposed plant will be in Wisconsin Rapids, WI, and will convert wood wastes to Fischer-Tropsch liquid and then into renewable diesel and renewable gasoline. NewPage Corp. of Mi-

amisburg, OH, recently acquired Stora Enso North America, the original applicant for this funding opportunity announcement.

NewPage Corp. is the largest printing paper manufacturer in North America, based on production capacity, with more than US\$4.3 billion in *pro forma* net sales for the last 12 months ended Sept. 30, 2007. The company's product portfolio includes coated freesheet, coated groundwood, supercalendered and specialty papers.

New Page's partners include: TRI; Syntroleum; DOE's Oak Ridge National Laboratory; and Clean Tech Partners.

KEY PROJECTS WITHOUT DOE FUNDING (EXCLUDES PILOT LINES¹)

One modern bioenergy project has been announced in the pulp and paper industry. **Intrinsic** has announced the installation of a biomass gasifier at **Coastal Paper** in Wiggins, MS.

Weyerhaeuser, Kamloops, British Columbia, is in a syngas development program to fuel its lime kiln. **Parsons and Whittemore** has constructed a vegetable oil esterification-based biodiesel plant co-located with its pulp mill in Claiborne, AL². The synergy is shared utilities and increased thermal efficiency of both facilities.

The **KL Process Design** plant in Upton, WY, has constructed a 1.5 million gallon per year cellulosic ethanol plant using Ponderosa pine biomass³ as its raw material.

Finally, there are some exciting developments for modular design gasifiers and GTL units from **Community Power**, which has one BioMax unit running and another being installed.

KEY PROJECTS PROPOSED

Flambeau River Biofuels has proposed a demonstration plant to DOE⁴. This is a "Thermal 1" process pathway. The raw material is about 580 tpd of unmerchantable biomass and the output is about 5.8 million gallons of renewable fuel feedstock, superior to low sulfur crude and about 4 million BTUs of thermal energy per day for nearby Flambeau River Papers, Park Falls, WI. This integration helps make the per-barrel cost of the renewable fuel feed stock cheaper than the cost of oil.

New York has given a US\$10.3 million grant to **Catalyst Renewables Corp.** to help fund a 130,000 gallon per year cellulosic ethanol pilot plant line in upstate New York⁵. This is a "Sugar 4" process pathway. The project is aimed at extracting hemi-

cellulose from woody portions of biomass going to an existing solid fuel boiler that produces power for sale to the utility grid and steam to a local facility. Biomass gasification has recently been added to the project.

Colusa Biomass is proposing a plant in California to produce 12.5 million gpy of cellulosic ethanol from rice straw using enzymatic hydrolysis followed by fermentation, which is a "Sugar 2" process pathway⁶.

Potlatch Corp., with financial help from Winrock International, developed a comprehensive biorefinery project for its mill in McGhee, AR⁷. The biomass feed was specified to be about 2,000 BDT per day and the output was about 2,300 barrels per day of renewable refinery feedstock, plus about 150,000 pph of steam for the mill and about 14 million BTU/hr of tail gas for the lime kiln. Because of integration, thermal efficiency was expected to be as high or higher than others have achieved with larger gas to liquids processes⁸.

The University of Florida has announced that **Florida Crystals** is the recipient of a US\$20 million state grant to build a 1-2 million gpy cellulosic ethanol plant to be used simultaneously as a commercial facility and a development plant⁹. Florida Crystals harvests 10 million tons of sugarcane annually, refines four million tons of sugar and operates a 75 megawatt renewable power plant at Okeelanta, FL.

Energy Quest and **Willow Industries** have announced a joint venture to construct a 6 MV facility powered by the Quest downdraft gasifier.

The Louisiana Economic Development Corp. has approved a grant for the Tyson Food-Syntroleum joint venture called **Dynamic Fuels**. The facility will use technology to convert animal fat to biofuel.

Verenium has announced a 30 million gallon per year cellulosic ethanol facility in Jennings, LA.

DOE BIOREFINERY ACTIVITIES

In 2006, President Bush began to speak about cellulosic ethanol and the DOE issued its "Section 932 proposal" to fund up to 40% of a limited number of cellulosic ethanol plants that met four quantifiable criteria. On Feb. 28, 2007, the DOE announced up to US\$385 million in matching funds for six cellulosic ethanol plants that would have an installed cost exceeding \$1.2 billion¹⁰. (Details of each DOE project can be found in *Paper360*⁹, June/July 2007, pg 18-20.)

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Comparison of Projects

Figure 1 shows some critical technical information for the DOE-funded projects and a typical dry mill corn ethanol plant. Other projects can be added for comparison. Critical techno-economic data includes process technology, capital costs, product yields and capital effectiveness, which is capital per gallon per year.

The comparison data in Figure 1 is taken from published information (a lot of background data is still not available). For example, reclaimed heat is not known for all projects and must be included in the calculations. Cost of raw material, operating cost per gallon, and energy ratio information is not yet available and needs to be added for a more complete evaluation. ³⁶

Project	Technology	Capital Cost (\$ millions)	Yield (gal/ton)	Capital Effectiveness (\$/gal/yr)
Announced Projects				
Abengoa	Gasification & GTL	190 or more	79	more than 16.7
Alico	Gasification & fermentation	83 or more	75+ power, etc.	less than 4.0
BlueFire	Hydrolysis & fermentation	100 or more	68	about 5.3
Broin	Enzyme & fermentation	200 or more	83	Cannot break out
logen	Enzyme & fermentation	200 or more	~71	about 11.1
Range	Gasification + GTL	~225	92	About 5.8
Corn ¹⁷	50 Million GPY "dry mill"	~100	80	new about 2.0

Figure 1. Project Comparison (yield does not account for all BTUs)

REFERENCES:

¹ Pilot lines like Abengoa at York Nebraska, Verenium (formerly Celunol) at Jennings Louisiana, Range Fuels at Broomfield, Colorado and Mascoma/UT in Monroe County, Tennessee are critically important but not the focus of this article.

² Press Release, Independence Renewable Energy Corp., Sept. 27, 2006.

³ www.klprocess.com

⁴ Demonstration Plant-Biomass Fuels to Liquids submitted to DOE Funding Opportunity DE-PS36-07G097003

⁵ DOE Press Release, New York Governor Announces \$25 Million to Develop Cellulosic Ethanol Facilities

⁶ Private communication with Tom Bowers

⁷ Tom Belin, "Demonstration of the Forest BioRefinery at the Potlatch, Cypress Bend Mill", 2006 Forum on Energy, May 15-17, 2006, Appleton WI.

⁸ Private communication with Dan Burciaga, President TRI

⁹ University of Florida press release Aug. 23, 2007

¹⁰ DOE press release Feb. 28, 2007, S. W. McLean.

(This is the third in a four-part series that began in the March issue of Paper360°. The series was originally scheduled to appear in three parts but has been extended to four to fully cover this important topic.)

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