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FUEL



Not So Run of the
MILL

The forest products industry has years of experience in conversion technology, and cellulose and lignin separations. The industry is now looking to develop its pulp and paper mills into biorefineries with ethanol as a focus.

By Anduin Kirkbride McElroy

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Pulp and paper mills, many of which were built in the 1800s, haven't changed much in their many decades of operation. Of course, product improvements and process efficiencies have been developed and implemented, but the basic infrastructure and purpose of the mills remain the same. All this is about to change as pulp and paper mills are positioned to become the next biorefineries.

A biorefinery is generally defined as a renewable mirror of a petroleum refinery, where a variety of fuels, chemicals and power are produced from one source, and the mix of these products can be adjusted based on market value. The forest products industry is now evaluating its potential as biorefineries. As biorefineries, pulp and paper mills could utilize technologies such as gasification, biomass boilers, biodiesel and ethanol production. Such technologies would reduce or eliminate fossil fuel consumption, provide value-added products and streamline pulp production.

"I have always taken the approach of an integrated biorefinery," says Arthur Ragauskas, a chemistry and biochemistry professor at the Institute of Paper Science and Technology at Georgia Tech. Since 1989, Ragauskas has studied process efficiencies and waste-stream utilization in the forest products industry. He maintains that the future of the industry is broader than paper. Mills will continue to make paper but producers have begun to explore how they can take the waste streams to make fuels or chemicals, he says.

This is a hot topic in the pulp and paper industry, says Glenn Ostle, editorial director of *Paper360*, the official publication of the Technical Association of the Pulp and Paper



Ragauskas



In the future, paper may be one of many products produced at pulp and paper mills.

PHOTO: Glenn Ostle/Paper360

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Industry and the Paper Industry Management Association. He explains that the industry sentiment is torn between a desire to diversify into a burgeoning market and reluctance because the costs are so high. There are also questions about policy and technology that tend to make diversification a big gamble, he says.

Nevertheless, many mills are moving forward with biomass projects. For example, Evergreen Pulp Inc. in Eureka, Calif., has proposed a project to gasify wood waste and to use the resultant biogas to power the mill. Many companies already burn the spent pulping liquor (or black liquor) in conventional boilers, primarily to recover the pulping chemicals, but the process also generates enough power to make the process the largest contributor to U.S. biomass energy generation, according to the U.S. DOE Office of Energy Efficiency and Renewable Energy. Now, some companies are looking toward gasification of the black liquor, which



Plamann

could substantially improve the efficiency of the process.

"Biomass-to-gas is one of the interests we've seen come through our office quite a bit," says Kris Plamann, business development manager of Baisch Engineering in Wisconsin. "It will bring down pulp and paper mills' overall energy costs, so long-term it's an overall energy saver. But everyone wants to be the second to do it. Now that some mills have been funded to be the first, everyone can follow and learn from their experience."

Plamann says biomass utilization for energy production will likely be the first phase in a mill's transition into a biorefinery. In the past year, Baisch Engineering has seen a dramat-

ic increase in mills inquiring about various biorefinery technologies, she says. "A lot of pulp and paper mills right now are looking at ways to reduce energy costs because that's such a huge part of their costs and competitiveness," Plamann says. "Eventually, they'll get into the actual production of ethanol. Paper mills are looking at their potential to make cellulosic ethanol because they have so much biomass available." For revenue generation, ethanol is probably the most promising product that could come from pulp biorefineries.

'A pulp mill has a lot of attractive features for making bioethanol. It has permits, transportation infrastructure, is located close to wood resources and agriculture resources, and it has a workforce that is used to working with wood. You have a lot of intrinsic advantages.'

Pulp and paper mills that choose to start producing ethanol face aggressive competition. Western Biomass Energy in Upton, Wyo., is being developed by KL Process Design Group of Rapid City, S.D., as a stand-alone 1.5 MMgy ethanol demonstration plant that would produce ethanol from waste wood. It claims to be the first biomass ethanol plant that doesn't use acids or that fully depends on specialized enzymes to release cellulosic sugars from lignin fibers. The plant started grinding wood in August.

Meanwhile, Massachusetts-based Mascoma Corp. announced in July that it plans to build a wood-to-ethanol plant in Michigan, although no details have been announced regarding when construction or production would start. Range Fuels Inc., which is owned by Khosla Ventures LLC, also announced its intent to start construction on a cellulosic ethanol plant this summer, although at press time ground had not been broken on the 100 MMgy facility. The company intends to convert wood waste from Georgia's forestry industry into ethanol.

Despite the looming competition, mills as biorefineries have many advantages over stand-alone cellulosic ethanol plants. "The [stand-alone] cellulosic plants are being developed in places where the biomass is, but not necessarily near

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water and power,” Plamann says. “Paper mills are built along the waterways, so [ethanol production] is a natural fit for the pulp and paper industry.”

Ragauskas agrees. “A pulp mill has a lot of attractive features for making bioethanol,” he says. “It has permits, transportation infrastructure, is located close to wood resources and agriculture resources, and it has a workforce that is used to working with wood. You have a lot of intrinsic advantages.” However, wood handling is just one part of the process, and pulp and paper mills will require partnerships with companies experienced in saccharification and fermentation, Ragauskas notes.

Another attractive incentive to make ethanol at pulp mills is that it could actually enhance the efficiency of the plant. “Ethanol plants would be a good fit for Kraft mills that have an excess of biomass generated steam,” says Bob Benson director of research and development at GreenField Ethanol, who is referring to the Kraft process that is practiced at most pulp and paper mills today. “Removing hemicellulose from the wood chips prior to pulping reduces the mass of dissolved wood components that pass through the recovery furnace. The production capacity of some pulp mills is limited by the recovery furnace operating rate. These mills could generate the same amount of pulp and produce ethanol as a byproduct.”

Benson points out that yet another advantage for pulp and paper mills over stand-alone cellulosic ethanol plants is that mills separate the wood parts. Thus that cost is already factored into the pulp and paper process. Through the hydrolysis of wood chips with water or other solvents (possibly ethanol) prior to pulping, Benson says about half of the hemicellulose, or about 10 percent of the wood dry matter, could be extracted. This extract could be further hydrolyzed to sugar and then fermented to ethanol.

Hemicellulose is a byproduct which is largely being wasted at mills today. It is often burned in the boilers with the lignin after the cellulose has been sorted out for pulp production. To make better use of the hemicellulose it must be separated from the lignin. Ragauskas says pre-extraction of hemicelluloses before pulping could make about 14 million tons available to the biofuels industry annually while at the same time enhancing the production of Kraft mill pulps, as



PHOTO: Glenn Ostler/Paper360

Flambeau River Papers LLC is planning to install a biomass boiler or gasifier. Additionally, Flambeau River Biorefinery LLC, which would produce 20 MMgy of cellulosic ethanol, is being developed adjacent to the paper mill in Park Falls, Wis.

described above. He is careful to note, however, that not all hemicelluloses can be extracted, as some are necessary to produce quality pulp.

Although the buzz in the industry has gone so far as to predict that paper may even be a byproduct at mills in the future, it is more likely that paper will remain a primary product. Pulp still has a higher selling price per pound than ethanol, and the market demands that transportation fuel remain cheap. Therefore, as biorefineries, mills must continue to

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maximize the returns on all of its products.

Ethanol production at pulp and paper mills is not new. In the 1940s and 1950s, there were about 40 mills that also produced alcohol, according to Benson. Before he moved to GreenField, he was the vice president of research and development at Tembec Chemical Products Group and has been working to produce ethanol from hemicellulose and pentose the past 30 years. Today, the Tembec mill in Temiscaming, Quebec, is the only known pulp mill in North America that currently produces ethanol. The company ferments spent sulfite liquor (wood hydrolysates) with the yeast *Saccharomyces cerevisiae*, which is also used in corn-to-ethanol fermentation. Tembec produces 15 million liters per year (4 MMgy) of alcohol, most of which goes to the food and beverage market.

'If you look at patterns within the United States, big changes in industry come from small companies that grow. New products, new chemicals and new materials—they will lead the revolution of some of these conversion technologies.'

Tembec produces paper using the sulfite pulping process as opposed to the Kraft process. The technology of taking the liquor that comes out of sulfite pulping is very well known, Benson says. However, sulfite pulping is not commonly practiced today because it yields less cellulose pulp compared with the more common Kraft process. This is one reason why alcohol production at mills dropped off and it became necessary to develop alcohol production technologies that are compatible with the Kraft process.

One such development is the American Value Added Pulping (AVAP) process, developed by Atlanta-based American Process Inc. The company has entered into an agreement with Flambeau River Biorefinery LLC, a 20 MMgy cellulosic ethanol biorefinery under development. The biorefinery will be collocated with Flambeau River Papers LLC, a paper mill based in Park Falls, Wis. AVAP is a patent pending, hydrolysis-based technology focused on converting hemicellu-

lose to ethanol. The major pulping chemical is alcohol. Flambeau River Biorefinery President Ben Thorp says the process completely separates the cellulose and lignin from the liquor. "What's left is a broth containing the pulping alcohol and the hemicellulose," he says. "We heat it to the boiling point of the alcohol, evaporate and recover the alcohol, and reuse it in the pulping process." This leaves the hemicellulose ready for saccharification and fermentation.

Thorp tells *Biomass Magazine* that funding is critical for the project to go forward. In August, Flambeau applied for money from the U.S. DOE's third round of funding for cellulosic ethanol projects. Thorp expects to start construction upon acquisition of financing and permitting.

Another venture, announced in late August, would produce a variety of biofuels from gasified black liquor. Swedish-based Chemrec AB and Ohio-based NewPage Corp. are exploring the production of renewable, biomass-based fuels at the NewPage paper mill in Escanaba, Mich. The plant would employ Chemrec's black liquor gasification (BLG) technology, which converts waste from the paper pulping process into syngas that would then be processed into biofuels. The technology could enable the Escanaba mill to produce up to 13 million gallons of liquid biofuel per year. No timeline for the project was announced.

These projects may be the front-runners in the effort to get pulp and paper mills to produce cellulosic ethanol. Announcements of pilot plants and mill trials continue to pop up, while the first phase of biorefinery development for mills—biomass power—is becoming more prolific. Within five to 10 years, Plamann predicts that many mills will be operating as biorefineries, and that the trend will spread across the United States and Canada in less than 15 years.

Ragauskas says it's time to involve more young and talented people in the industry. "We're on the cusp of transition into the integrated biorefinery," he says. "If you look at patterns within the United States, big changes in industry come from small companies that grow. New products, new chemicals and new materials—they will lead the revolution of some of these conversion technologies." **BIO**

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