Forest Products Laboratory

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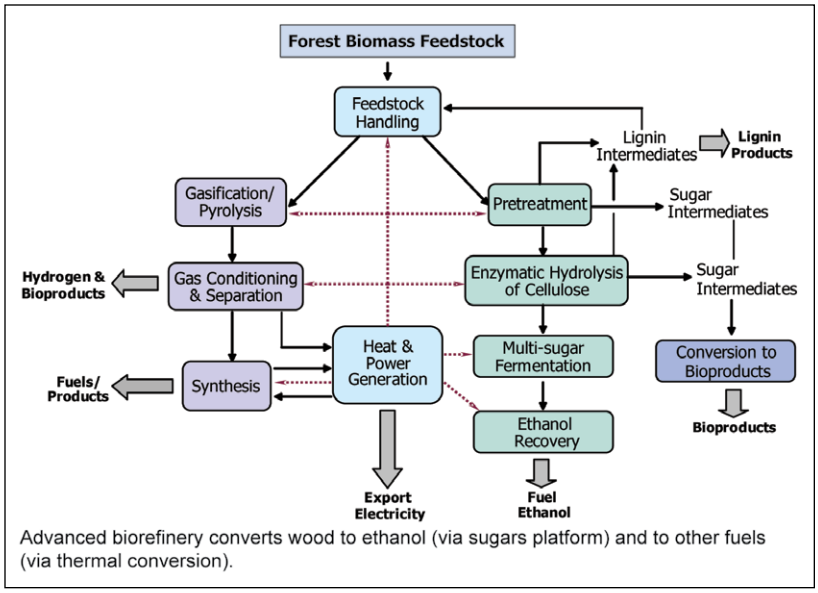
A Chemical Cornucopia: Using Forest Biomass

By George Couch, Public Affairs Specialist



Advanced biorefinery converts wood to ethanol (via sugars platform) and to other fuels (via thermal conversion).

From Atlanta, Georgia, to Appleton, Wisconsin, to Cypress Bend, Arkansas, to Madison Wisconsin, one word often overheard when forest products people talk business is "biorefinery."

"The biorefinery concept sparks considerable interest because it could represent the solution to several major problems facing both forest managers and the forest products industry," said Chris Risbrudt, Ph.D., director of the USDA Forest Service Forest Products Laboratory (FPL). "With forest biomass used as feedstock, biorefineries could produce a variety of fuels and high-value chemicals that could help pay for desperately needed forest management activities. At the same time, they could also reduce energy costs while creating new sources of income for the pulp and paper industry," Risbrudt said.

That latter benefit put biorefinery on the agenda at an international conference on nanotechnology and the forest products industry in Atlanta in April and at a meeting on energy conservation in Appleton in May. The Atlanta conference was sponsored by TAPPI, an international trade association of the pulp, paper, packaging and converting industry, and FPL. The Appleton meeting, cosponsored by the Center for Technology Transfer (recently renamed CleanTech Partners, Inc.), Focus on Energy, Wisconsin Paper Council, and TAPPI, showcased environmentally friendly approaches to reducing industrial energy costs and fossil fuel usage.

Two types of biorefinery are contemplated. A stand-alone biorefinery uses heat and chemical processes to completely convert woody biomass into fuel-grade ethanol, syn-gas, commodity chemicals, plastics feedstock, pharmaceuticals and other high-value chemicals. An integrated biorefinery, installed as part of a pulp mill, extracts and converts some components prior to pulping and converts waste by-products of the pulping process. Some of the syn-gas and other fuels produced by the refinery would be used in the pulping process.

Biorefineries are a logical development of the forest products industry for several reasons. The industry already controls much of the raw material and necessary infrastructure. Pulp and paper mills, for example, are geared to collect and process biomass. Also, the industry itself, which has been hit hard by new global competition, would benefit significantly.

Benefits extend beyond the forest products industry. By preserving high-paying skilled jobs in many rural communities, U.S. national and regional economies would be strengthened. And because using forest material is carbon neutral, using it in place of fossil fuels would reduce greenhouse gas emissions. Use of forest material would

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"We Have Some of the Worst Problems…"

New research/demo house shows southern homes can stand up to nature's nastiest

By Rebecca Wallace, Public Affairs Specialist

There's no place like home. But if your house is susceptible to damage from termites, moisture, or high winds, "home, sweet home," can quickly become a huge headache.

To address major issues that plague wood-framed buildings in the southeastern United States, a new research and demonstration house is in the works at Mississippi State University (MSU).

Dr. Terry Amburgey, project coordinator and professor in the Forest and Wildlife Research Center at MSU, is convinced that a regional approach is the best way to address housing durability, energy efficiency, and indoor air quality issues. The MSU research house will focus on these three main problem areas.

Amburgey says it's important to realize that different climatic regions require different types of housing technologies based on environmental factors the buildings will be exposed to.

"In the southern region, we have some of the worst problems, such as heavy rainfall, high temperatures and humidity, hurricane-force winds, termites, and decay fungi," Amburgey says. "By developing a research and demonstration house that focuses on issues in the southeastern United States, we are better equipped to take a closer look at our regional problems and make a regional effort to address them."

A recent summary of the research project states that the overarching goal of the demonstration house is to "develop and demonstrate design, engineering, construction, landscaping and applied biology techniques that will increase both the durability and livability of homes in the southern climatic region."

Initial research projects focus on preventing biodegradation through moisture control and termite resistance, maintaining structural integrity during high-force winds, and maximizing energy efficiency. However, these topics are only the beginning—the house is designed to be dynamic, with research projects evolving or being added as data are collected.

Interestingly, some benefits of the house design will be seen immediately, rather than after years of research. "Right out of the box we expect to reduce energy consumption of this house by 75 percent compared to the average house in the southern region," says Amburgey.

The research and demonstration house is also designed to serve as a teaching tool for many groups, including

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MSU and other university students and faculty, contractors, or others involved in the building sciences. Amburgey hopes this is one way the results of their research will be put to real-world use.

"We hope to show the public that energy efficiency, durability, and good indoor air quality do not have to impact the aesthetics or function of a house," says Amburgey. "We also plan to use the house as a classroom to train a cadre of people involved in local construction. They have the ability to initiate widespread change by implementing new technologies and helping them gain acceptance in the building community."

Mississippi State University's research and demonstration house will be used to study climate-specific housing issues.

The design of the demonstration house is complete, and the construction site at Mississippi State University has been chosen. Currently, researchers are developing specific plans for experiments to be conducted at the house, and those involved hope to break ground within the next three months.

The USDA Forest Service Forest Products Laboratory (FPL) in Madison, Wisconsin, is also the site of a research and demonstration house, but research there focuses mainly on issues faced in a northern climate. Mississippi State University and FPL have a long-standing partnership that is playing a key role in the development of MSU's new research structure.

"The great thing about partnering with FPL is that we don't have to reinvent the wheel," says Amburgey. "They have researchers with expertise who can advise us on the technical aspects of conducting research in a demonstration house."

According to Assistant Director Michael Ritter, FPL will assist with instrumentation, research layout and design, and data collection methods to evaluate issues specific to the southern climate.

FPL provided funding for MSU's research and demonstration house through their partnership in the Coalition for Advanced Wood Structures (CAWS). CAWS brings together representatives from universities, industry, and government to promote sustainable use of forest resources, improve the economy, and improve the performance of wood structures.

"Promoting partnerships through CAWS, not only between FPL and the universities, but among the universities themselves, greatly enhances our ability to function as a team and look at issues of both regional and national importance," says Ritter.

External partnerships aren't the only ones necessary to make this project happen. Partnerships among the staff at MSU are vital to the success of this research program.

In the beginning stages of planning for the demonstration house, Amburgey quickly realized that a project of this magnitude is not a job that he could tackle on his own. So he gathered a team of researchers from six departments at MSU to work together on developing the housing research program: architecture, mechanical engineering, civil engineering, electrical engineering, landscape architecture, and forest products. The departments will all be involved in various stages of design, construction, and maintenance of the research structure to maximize its utility as a facility for conducting housing-related research.

"There are a lot of benefits to tackling the same problems from different areas of study," Amburgey says. "This multi-faceted approach to research is something we also hope to demonstrate so others can emulate it."

He hopes the demonstration house at MSU will be an example of how much can be gained by taking a multidisciplinary approach to research. Through this project, Amburgey and his research team are working to create a template that other regions can use to develop their own climate-specific housing research.

Ask FPL

We get thousands of questions each year about wood and paper products. In each issue of NewsLine we print what we feel are some of the best. Here are two we recently received.

Questions?

Contact us at
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How are knots formed in trees and what is their effect if they end up in a piece of lumber?

A knot is a portion of a branch that has become incorporated in the bole, or trunk, of a tree. Two types of knots can be formed—intergrown and encased. Intergrown knots are formed while the branch remains alive and growth continues at the junction of the limb and the bole of the tree. Encased knots are formed after the branch dies; the bole continues to grow and encloses, or encases, the dead limb. Encased knots tend to be less problematic with regard to most mechanical properties of lumber.

Mechanical properties of lumber are usually lower in sections containing knots than in clear, straight-grained sections. Knots influence the mechanical properties of lumber because they interrupt the continuity and change the direction of the wood fibers. The degree to which knots influence mechanical properties depends largely on their size, location, shape, and soundness. How they affect lumber in service depends in part on the type of stress to which the lumber will be subjected. For example, a knot has a greater effect on the strength of wood stressed in axial tension that it does on strength in axial compression. In axial tension, a knot on the edge of the piece has a greater effect than a knot in the middle of the piece.

I have noticed that the wooden handles on several of my tools have loosened over time. What could be causing this?

One possible cause for the loosening of your tool handles is a change in the moisture content of the wood. Wood in service is exposed to both long-term (seasonal) and short-term (weekly) changes in the relative humidity of the surrounding air. These conditions can affect the moisture content of the wood, which, in turn, changes the dimensions of the wood. Wood swells when gaining moisture in the cell walls and shrinks when losing moisture from the cell walls. This shrinking and swelling can result in problems such as loose tool handles or gaps in wood flooring.

Wood is often dried before being manufactured into a product, with the objective of bringing the moisture content of the wood close to what the finished product is expected to have in service. However, actual conditions can often differ from what is predicted. Moisture content changes can be slowed, but not prevented, by protective coatings, such as varnish, lacquer, or paint. More information can be found in our Wood Handbook at http://www.fpl.fs.fed.us

New Forest Products Society VP visits FPL

Carol Lewis, newly appointed Executive Vice President of the Forest Products Society (FPS), is introduced to the world of wood anatomy by FPL botanist Michael Wiemann. Lewis, who has over 15 years of experience in education and management of not-for-profit organizations, was named by the FPS Executive Board to replace Arthur Brauner, who retired January 1, 2006.

A Chemical Cornucopia: Using Forest Biomass

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improve the diversity and security of the nation's energy supply and ease dependence on foreign fossil fuel. Forest products mills are located throughout the country, generally close to the supply of bio-based fuels. And biomass is an abundant, renewable, sustainable resource.

Cypress Bend, Arkansas, might become the site of an integrated biorefinery. Potlatch Corporation announced early this year that it was studying the feasibility of a commercial-scale integrated biorefinery at its Cypress Bend pulp and paperboard mill. A company vice president, Harry Seamans, said that preliminary estimates indicated a biorefinery could reduce natural gas usage at the mill by 1.6 million MMBTU (about 1.6 billion cubic feet) per year and reduce purchased electricity by 80,000 MWH per year. That's enough natural gas to supply 20,000 homes and enough electricity to power as many as 8,000 homes.

As currently envisioned, Potlatch would bring agricultural and forest waste biomass from throughout the Mississippi Delta and southeast Arkansas to the Cypress Bend mill where gasification and catalytic processes would convert it to a crude oil to be further refined into fuel products and other chemicals. The company is currently in the process of completing the feasibility study.

At FPL, in Madison, Wis., several research projects aim at helping make the forest biorefinery concept a practical reality that will benefit the nation's forests as well as the forest-based industry.

One project under the direction of research microbiologist William R. Kenealy, Ph.D., has led to a new pretreatment for wood chips that reduces the electrical energy required for the thermal mechanical pulping process used to make paper, releases fermentable sugars from the chips that can be used to make ethanol, and can result in stronger paper after the chips are pulped. The pretreatment process, which is covered by a joint provisional patent with Biopulping International Inc., involves treating the chips with heat and a chemical. The process, according to Kenealy, is both technically and commercially feasible.

In another project at FPL, microbiologist and senior scientist Tom Jeffries, Ph.D., has worked with specialized strains of yeast that are capable of fermenting xylose in woody biomass for producing ethanol, xylitol and other byproducts. In an integrated biorefinery, the xylose would be extracted prior to pulping, and some of the ethanol so produced would be used to provide heat and generate electricity for the pulp mill and paper plant. Last year, Xethanol Corporation licensed rights to Jeffries's patented process (see *NewsLine*, Fall 2005, vol.4, issue 4).

Another project underway at FPL is evaluating pretreatment of wood chips prior to pulping or being used in the manufacture of medium density fiberboard (MDF). One method studied extracted large amounts of xylose, which in a biorefinery could than be converted to ethanol. Other studies are looking at new and unusual or other high-value chemicals that can be produced in a biorefinery using waste feedstock or byproducts from pulp and paper mills.

"Our challenge is to discover more high-value chemical products that can be produced from woody biomass, especially those products that can only be produced from the unique lignocellulosic materials that need to be removed from our nation's forests," said Ted Wegner, Ph.D., assistant director at FPL.

Advancing the forest biorefinery idea is one of seven core technology platforms of the Agenda 2020 Technology Alliance, which seeks to accelerate research and the demonstration and deployment of breakthrough technologies. The other platforms are: nanotechnology, breakthrough manufacturing and technologies, next-generation fiber recycling and utilization, positively impacting the environment, advancing the wood-products revolution, and a technologically advanced workforce.

Originally launched in 1994 by AF&PA and the Dept. of Energy to promote energy efficiency in forest products manufacturing, Agenda 2020 is an industry-led partnership with government and academia that seeks to advance the forest products industry through innovation in processes, materials and markets. Industry is represented by the American Forest & Paper Association (AF&PA), the national trade association of the forest products industry. Additional participants in Agenda 2020 include the Society of Wood Science and Technology, the Forest Products Society, TAPPI, and the USDA Forest Service.

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Chris Risbrudt
Director

Partnership Formed with Chinese Academy of Forestry

In January 2006, FPL and the Chinese Academy of Forestry (CAF) signed a Memorandum of Understanding (MOU) signifying mutual interest in forest products utilization research. FPL and CAF agreed to promote scientific discussion and exchange and to foster cooperation and collaboration between the two organizations. FPL hopes to welcome a visiting scientist from CAF this fall. Pictured here as they sign the MOU are Mme. Zehui Jiang, professor of wood science and President of the Chinese Academy of Forestry, and Chris Risbrudt, director of FPL.