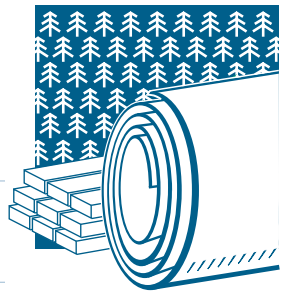
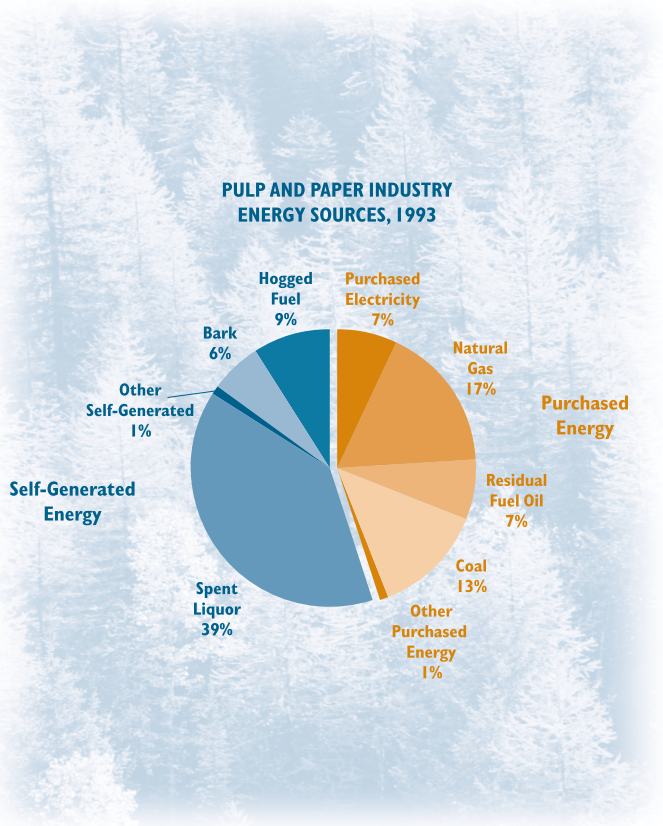
America's vast forest resources have helped make the U.S. forest products industry a world leader. The industry produces over $267 billion in wood and paper products each year. Materials from these products are used by consumers every day for communication, shelter, sanitation, and protection.



Forest Products Industry

PROFILE



Value of Shipments	$253.1 billion
Employment	1.23 million
Capital Expenditures	$12.1 billion
Net Trade Balance	-$7.63 billion
Net Energy Consumption	3.16 quads

INDUSTRY SEGMENTS

The U.S. forest products industry is divided into two major segments: lumber and wood products, and pulp and paper products. The lumber and wood products segment processes solid wood products and grows, harvests, and processes wood and wood fiber. In 1997, the lumber and wood products segment shipped about $103 billion worth of products.

The pulp and paper segment manufactures pulp, paper, and paperboard products from virgin and recycled fiber.

Although only 16% of the world's pulp mills are located in the United States, the United States produces 35% of the world's pulp and close to one third of the world's paper. This equates to 82 million tons of paper and paperboard and 10 million tons of market pulp.

Industry facilities range from large, state-of-the-art mills to small, family-owned sawmills. These mills use resources from approximately seven million individual woodlot owners.

EMPLOYMENT

The U.S. forest products industry employs 1.23 million people directly and ranks as one of the top 10 manufacturing industries in 46 of the 50 states. In 1997, the paper segment employed 575,000 workers at an average hourly wage of $16.17, which exceeded the average worker's hourly pay by about 32%. Average hourly wages for the entire forest products industry that year were $13.65.

CAPITAL INVESTMENT

The forest products industry is one of the most capital-intensive industries because of the high cost of papermaking and pollution control equipment. On average, the paper industry has invested more than $120,000 per worker.

COMPETITION

Following decades as a global leader, the U.S. forest products industry is increasingly challenged by its traditional competitors, such as Canada, Scandinavia, and Japan, as well as emerging nations like Brazil, Chile, and Indonesia.

Long-term competitiveness in today's global economy will require enhanced financial performance through improvements in energy and capital efficiency. In particular, the industry must focus on cost-effective use of recycled materials and reduction of energy costs.

ENERGY USE

The forest products industry is the third most energy-intensive industry in the United States — only petroleum refining and chemicals consume more energy. The industry uses approximately 3.16 quads of energy per year to make its products. Of this total, the lumber and wood products segment uses nearly half a quadrillion Btu (quad), and the pulp and paper segment uses 2.7 quad.

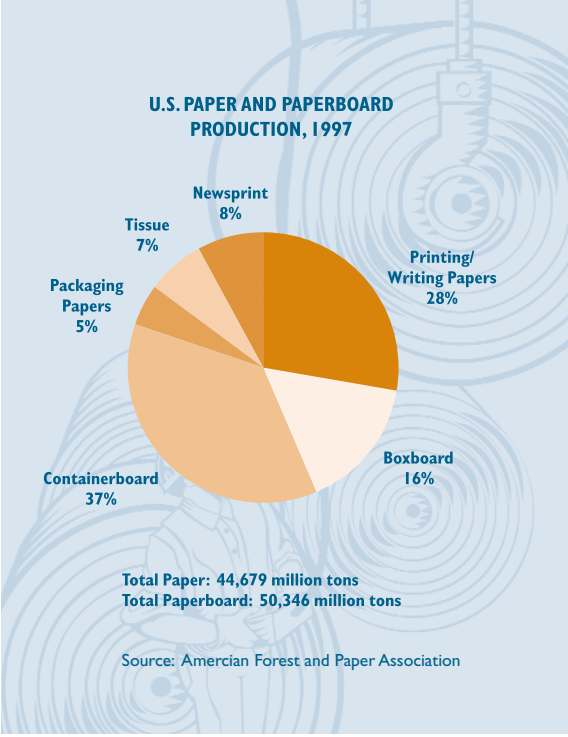
The industry makes significant use of renewable sources, including pulping liquor, bark, and wood. Currently, the industry is 54% energy self-sufficient, up from 36% in 1972. Even so, the industry spends about $8 billion on purchased energy each year, or nearly 3% of the value of its shipments. On average, these expenditures are nearly twice those of other industries.

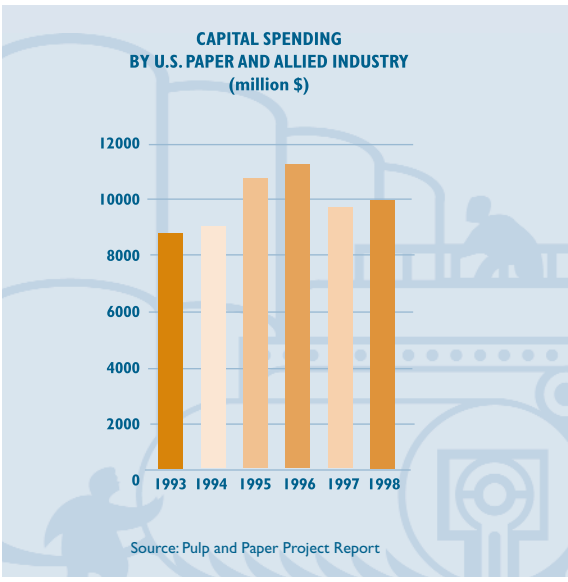
ENVIRONMENT

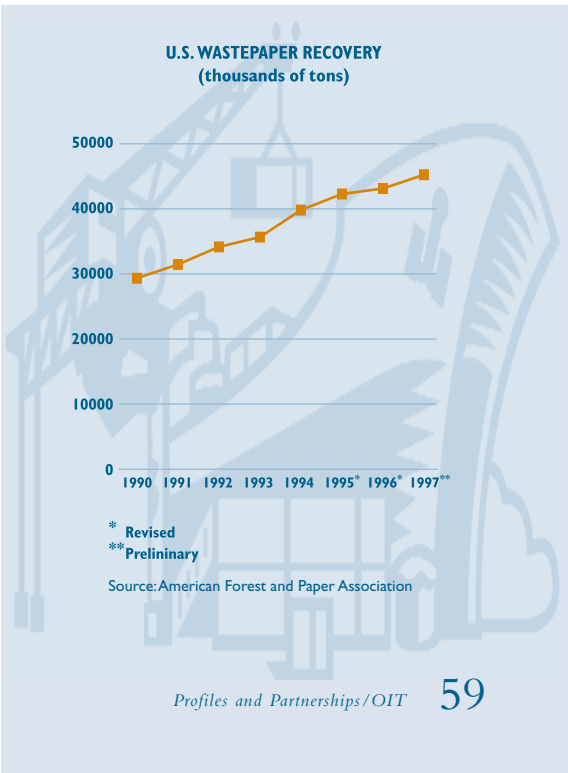
The industry spends more than $1 billion per year on environmental improvements and $2.9 billion on pollution control. These costs could increase dramatically due to stricter environmental regulations expected over the next decade. Currently, the industry is ahead of schedule in meeting emissions reduction goals developed by the Environmental Protection Agency.

RECYCLING

Waste recovery and recycling are critical to meeting environmental goals. These efforts also increase profitability by broadening the industry's raw materials base. About 45 million tons, or 42% of paper in the United States, is recovered for recycling each year. The industry is striving to increase this rate to 50% in the year 2000. In addition, more than 400 of the 547 pulp and paper facilities in the United States use recovered paper as one of the raw materials for papermaking, and more than 200 rely on it entirely.







Industry Vision and Roadmap

FOREST PRODUCTS INDUSTRY VISION

In 1994, the U.S. forest products industry, represented by the American Forest and Paper Association (AF&PA), published its strategic vision. *Agenda 2020: A Technology Vision for the Future* describes the industry's status, its broad goals and vision for the future, and technology requirements to achieve this vision.

Agenda 2020 describes how, despite a record of success, the forest products industry must now address the changing standards of society while remaining economically viable and globally competitive. Pressures on performance and competitiveness include decreased availability of land, increased interest in recycling, increased foreign competition, more demanding environmental requirements, and the need to reduce capital and energy intensity.

To meet these challenges, the forest products industry vision calls for precompetitive research, development, and demonstration in six technology areas:

- Sustainable Forestry
- Environmental Performance
- Energy Performance
- Capital Effectiveness
- Recycling
- Sensors and Control

PRESSURES ON PERFORMANCE AND COMPETITIVENESS

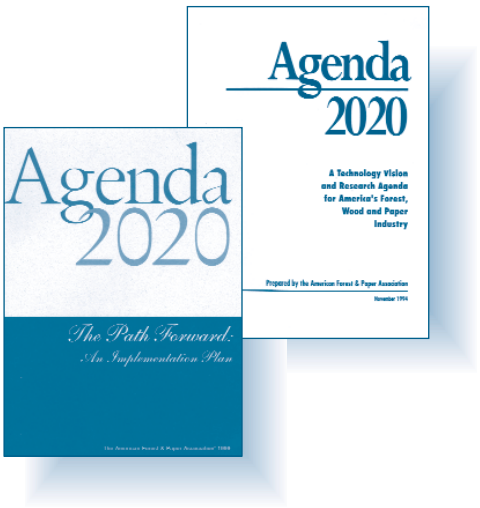
Decreased availability of land	In the future, less land will be available for planting and harvesting trees, which will drive up prices. It will also create pressure to use lower quality wood, which requires higher energy use.
Increased interest in recycling	Increased demand for recycling means lower grades of recovered fibers used. Upgrading this fiber is costly and energy-intensive.
Foreign competition	The United States increasingly faces competition from low-cost producers like Chile and South Africa, and from countries that have gained technological leadership, like Canada and Scandinavia.
More demanding environmental requirements	Compliance with new regulatory initiatives means unprecedented increases in capital expenditures, operating costs, and energy use.
High capital and energy intensity	Long-term viability demands improvements in energy and capital efficiency if financial performance is to reach satisfactory levels.

FOREST PRODUCTS INDUSTRY ROADMAP

Industry-led task groups, organized in cooperation with the AF&PA, were established for each of the six technology areas identified in *Agenda 2020.* Comprised of representatives from academia, government, national laboratories, and a broad cross-section of the industry, each group developed a detailed vision of the future for its specific area, identified technology required to achieve the vision, and developed a prioritized program or agenda. This information was used to develop research pathways, or roadmaps, for each vision area. These research pathways, known collectively as the *Implementation Plan,* describe:

- the link to *Agenda 2020*
- ongoing and future research needs
- desired research products and results

The pathways are updated annually by the task groups and provide the basis for competitive solicitations for research proposals.



FOCUS AREAS IN AGENDA 2020 IMPLEMENTATION

Sustainable Forestry	• Biotechnology • Basic Physiology of Forest Productivity • Sustainable Soil Productivity • Remote Sensing Technologies to Improve Forest Inventory and Stand Management
Environmental Performance	• Improved Margins of Environmental Safety • Process Alternatives Consistent with Pollution Prevention • Treatment Areas
Energy Performance	• Fuel Production and Enhancement • Fuel Conversion and Electricity Production • Environmental Impact of Energy Production and Utilization • Wider Use of Renewable Resources
Capital Effectiveness	• Systems and Process Technologies (what is built) • System Fabrication and Construction (how it is built) • System Efficiency (how it is operated)
Recycling	• Environmentally Benign Pressure Sensitive Adhesives • Improving Separation Technology • Sorting and Collection/Methodologies and Tools • Fiber-Fiber Bonding • New Technologies for Sludge Use and Disposal
Sensors and Control	• Actuators and Control Devices • Process Measurement and Diagnostics • Process and Product Models • Data Presentation, Interpretation, and Human Interface • Control System Effectiveness

Team & Partnership Activities

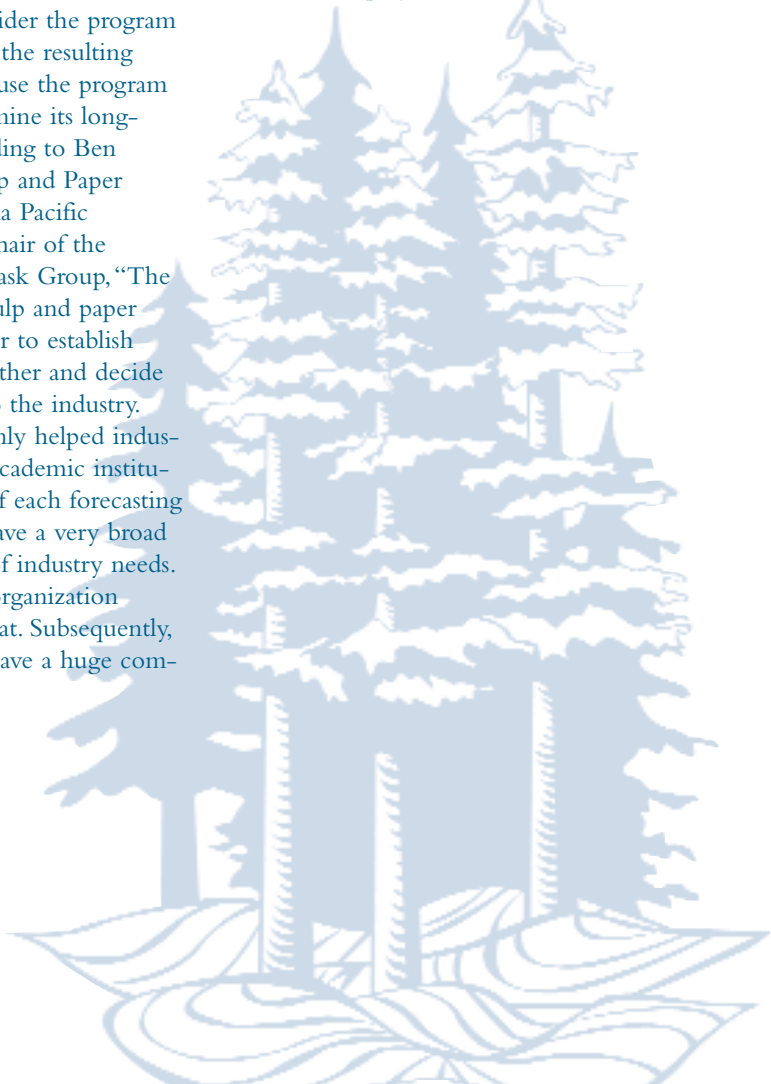
To manage the IOF process, OIT and AF&PA rely on the six task groups established for each of the technology focus areas. The groups define specific research needs, issue requests for proposals, and evaluate and recommend proposals for funding to the industry's chief technology officers (CTOs). CTOs make final recommendations to OIT's Forest Products Team, which cost-shares selected projects with industry. As of October 1999, 91 research projects had been funded through the forest products Industries of the Future process.

PROGRESS OF THE FOREST PRODUCTS IOF

The program has made significant strides since it became the first 'Industry of the Future' in 1994. Industry partners consider the program a success, not only for the resulting technologies, but because the program helped industry determine its long-term priorities. According to Ben Thorp, director of Pulp and Paper Engineering at Georgia Pacific Corporation and co-chair of the Capital Effectiveness Task Group, "The program helped the pulp and paper industry come together to establish rules for working together and decide what was important to the industry. These pathways not only helped industry, but suppliers and academic institutions as well. Instead of each forecasting on its own, we now have a very broad and very real picture of industry needs. No one company or organization could have afforded that. Subsequently, the IOF process will have a huge commercial impact."

LEVERAGING RESOURCES

Now that the industry has identified its goals and priorities, the Forest Products Team is developing partnerships with other organizations to leverage available resources. The team is currently developing partnerships with other government agencies, such as the U.S. Department of Agriculture (USDA). Currently, the USDA is cost-sharing nine projects with industry. OIT is also working with other DOE offices, including the Office of Power Technologies, to fund gasification research, one of the industry's most promising new technologies. In addition, the Forest Products Team works with several other IOF teams, including Agriculture and Chemicals, to cost-share R&D projects of mutual benefit.

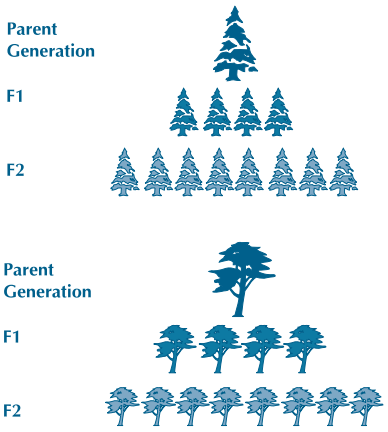


REPRESENTATIVE FOREST PRODUCT-RELATED PROJECTS IN OIT'S PORTFOLIO

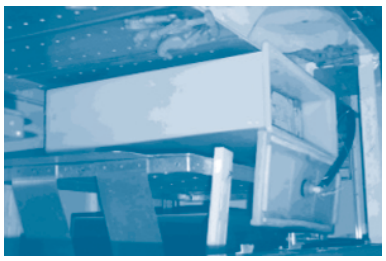
	SUSTAINABLE FORESTRY	ENVIRONMENTAL PERFORMANCE	ENERGY PERFORMANCE	CAPITAL EFFECTIVENESS	RECYCLING	SENSORS & CONTROLS
Forest Products Team						
•Acoustic Separation Technology					●	
•Biomass/Black Liquor Gasification Combined Cycle		●	●	●		
•Bleach Plant Capital Reduction				●		
•Intensively Managed Forests	●					
•Low-VOC Drying of Lumber and Wood		●				
•Marker-Aided Selection Methods	●					
•Methane de-NOx® Reburn Technology			●			
•Multiport Cylinder Dryers			●			
•Near Infra-Red Sensor						●
•Pine Gene Discovery Project	●					
•Productivity of High-Yield Hardwood Species	●					
•Removal of Wax and Stickies					●	
Industrial Materials						
•Materials for Kraft Recovery Boilers				●		
Inventions & Innovation						
•Acoustic Humidity Sensor						●
•Apparatus for Removing Bark from Whole Logs	●					
•Molten Film Paper Dryer			●			
NICE³						
•Chemicals for Increasing Wood Pulping Yield		●				
•Long Wavelength Infrared Drying System for Wood Fiber			●			
•Pallet Production Using Post-Consumer Wastepaper					●	
Sensors and Controls						
•Non-Contact Laser Acoustic Sensor						●

See "Selected Forest Products Portfolio Highlights" on the next two pages for additional information

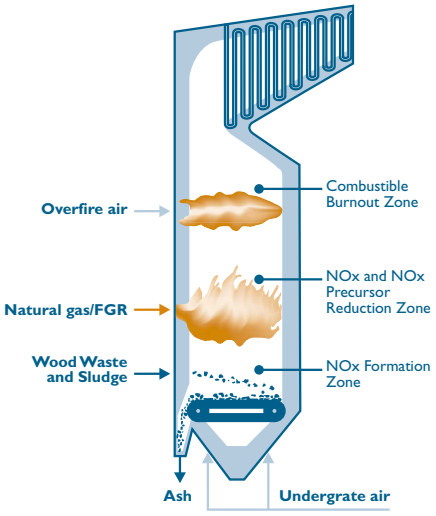
Selected Forest Products Portfolio Highlights



Researchers are developing tools to improve future planting stocks.

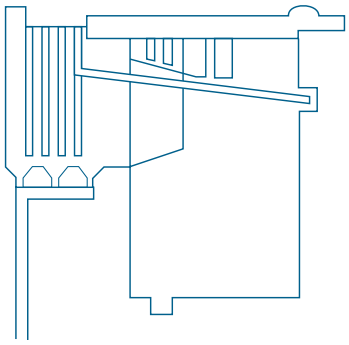


A charge of lumber loaded in a low-headspace vessel at Georgia Power's test center.

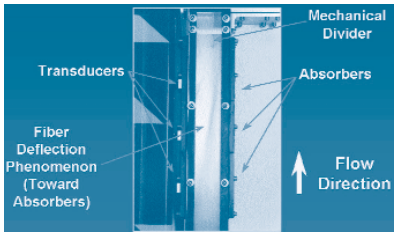


Spreader Stoker Boiler with Methane de-NOx® Reburn

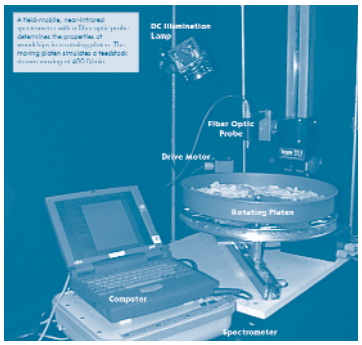
AREA	SUSTAINABLE FORESTRY	ENVIRONMENTAL PERFORMANCE	ENERGY PERFORMANCE
PROJECT	**Marker-Aided Selection Methods for Wood Properties**	**Low VOC Drying of Lumber**	**Methane de-NOx® Reburn Technology**
DESCRIPTION	Trees with certain genetic characteristics improve the quality of pulp, paper, and other wood products manufactured from them. Researchers at Oak Ridge National Laboratory and industry partners are using rapid analytical techniques to identify molecular markers in trees and associate these markers with the trees' genetic characteristics. This method provides foresters with tools to improve future planting stocks by selecting characteristics like overall wood density, fiber dimensions, and cellulose and lignin content.	Conventional wood drying processes release volatile organic compounds (VOCs), which contribute to the formation of smog. The Institute of Paper Science and Technology is working with project partners to develop and demonstrate a radio-frequency unit that removes VOCs prior to conventional drying. Radio frequency pretreatment of lumber reduces energy and capital costs, while removing over 70% of VOCs. The VOCs (principally terpenes) can be condensed and sold for use in making turpentine. The technology can replace expensive, energy-intensive VOC control equipment that many federal and state regulations now require.	Biomass, wood waste solids, and sludges are difficult to burn in stoker boilers because of their low combustion temperatures and high NOx emissions. A new technology called METHANE de-NOx® reburner may help to overcome these problems. With its partners, IGT is demonstrating the retrofit in a waste wood and sludge-fired stoker boiler at a Boise Cascade papermill. Results show a three-fold increase in sludge firing rates, an increase in boiler efficiency, a 50% decrease in NOx emissions, and a 30% decrease in natural gas use in co-firing. Annual savings of about $400,000 in sludge handling/disposal costs and $270,000 in fuel costs are anticipated.
PARTNERS	Oak Ridge National Laboratory Institute of Paper Science and Technology National Renewable Energy Laboratory University of Washington U.S. Forest Service Weyerhaeuser Company	Institute of Paper Science and Technology American Kiln Electric Power Research Institute Georgia-Pacific Corporation Georgia Power Potlatch Corporation	Institute of Gas Technology Detroit Stoker Boise Cascade Babcock and Wilcox Sargent and Lundy LCC



Researchers are developing tools to identify and minimize corrosion-related problems in black liquor recovery boilers.



A new separation technology takes advantage of the effects of acoustic radiation on fiber suspension.



An infra-red light helps researchers determine physical and chemical characteristics of wood chips.

CAPITAL EFFECTIVENESS

Materials for Kraft Recovery Boilers

Corrosion of boiler tubes reduces the energy efficiency of Kraft recovery boilers and can cause leaks that precipitate dangerous smelt/water explosions.

OIT's Advanced Industrial Materials program is working with Oak Ridge National Laboratory to identify the cause of cracking in coextruded tubing in black liquor recovery boilers. The objective is to develop alternative materials and procedures that minimize corrosion-related problems.

- Improve boiler safety
- Reduce downtime
- Decrease costs for equipment replacement

Oak Ridge National Laboratory
and numerous industry and other partners

RECYCLING

Acoustic Separation Technology

Currently, the forest products industry uses inefficient pressure-screen systems to separate fibers. More efficient separation technologies can eliminate problems like clogging and fiber damage, while increasing controllability and other benefits.

The Institute of Paper Science and Technology has found that fibers suspended in water migrate and reorient themselves when they interact with acoustic radiation pressure. The institute is exploiting this principle to separate fibers based on fiber width.

Additional applications are related to deinking and pulp-thickening operations and improved particle removal in closed water systems.

Institute of Paper Science and Technology
State of Georgia
Beloit Corporation

SENSORS AND CONTROLS

Near-Infrared Sensor

A project by the National Renewable Energy Laboratory and Ames Laboratory involves use of infra-red light to chemically analyze wood chips in real-time, which will help predict the quality of the final paper product. Researchers will use this technology on trees before they are harvested to determine physical and chemical characteristics of their feedstock, such as density, moisture, carbohydrate and lignin content. Pulp and paper mill operators will use this technology to monitor and control variations in the manufacturing processes.

National Renewable Energy Laboratory
Ames Laboratory
Weyerhaeuser Company
Champion International
Westvaco
Rayonier
Georgia-Pacific
Mead

For more information on OIT's Forest Products Portfolio, visit www.oit.doe.gov/forest