SEPTEMBER/OCTOBER 2017

Paper360°

TAPPI | PIMA AROUND THE INDUSTRY, AROUND THE WORLD

The Emerging Bioeconomy

PLUS:
PPI Top 100

ALSO:
RISI Latin American CEO of the Year; American Eagle is Ready to Compete; State-of-the-Art Tissue Pilot Plant; Drying Optimization at RDM Ovaro; Bioaugmentation in Wastewater Treatment; Vacuum System Best Practices; and more.

NOW FEATURING CONTENT FROM
Featured content by RISI
PPI
PULP & PAPER INTERNATIONAL

A Biorefinery Industry is Emerging

The forest biorefinery is more than just an idea—we have evidence that it's coming. One key is to look at the relationship between the technology and the way a region values its biomass.

BEN THORP, HARRY SEAMANS, AND MASOOD AKHTAR

The US corn ethanol industry processes more than 15 billion gallons of corn ethanol each year. The US biodiesel industry (using vegetable oil-based fatty acid methyl esters, or FAME) produces more than 2 billion gallons of diesel each year. The contributions of these "first generation biofuels" are well documented.

We also know that these industries are making significant product and process improvements. The average additional energy needed to make a gallon of corn ethanol has decreased from 37,000 BTU per gallon in 1994 to 23,832 BTUs per gallon in 2010. Some plants are now at half of the 2010 average. State policies are enabling some vegetable oil diesel facilities to make jet fuel in California.

But what does this mean for the forest products industry, and how does the forest products industry positively affect the environment by adding value to forests?

THE DEFORESTATION MYTH

Those outside of the forest products industry hold a misconception that industrial use of forests leads to heavy forest losses. Documentation is available that concludes the countries that create the highest value from wood also have the most sustainable forests. The economic driving forces for biomass or spent biomass will be enhanced by the bio-industry, and in future years it will be said that those countries with the highest value use of virgin or spent biomass will have the most sustainable agricultural practices.

Chapter 2 of the book *Sustainable Development in the Forest Products Industry* (edited by Roger M. Rowell, Fernando Caldeira, and Judith K. Rowell) documents how industrial use creates economic incentives to keep forests as forests. Chapter author Peter J. Ince, a research forester for the US Forest Service Forest Products Laboratory in Madison, WI, writes: "A common but simple hypothesis about global deforestation is that industrial timber harvesting and forest product demands are correlated with global deforestation. This hypothesis can be examined simply by comparing global data on timber harvest by region with data on changes in forest area and net carbon balance of forests…in general, the data show that global regions with the highest levels of industrial timber harvest and forest product output are also regions with the lowest rates of deforestation."

In other words, whether a region remains forested is really a function of the value placed on the wood and biomass by industry.

North America's forests became a carbon sequester after about 1915. Figure 1 shows that, outside of Europe, all other countries are carbon releasers. As Ince explains, countries that do not have a high value use for wood generally end up not managing their forests for sustainability; instead, they deforest their lands for other uses.

In fact, the figure shows that the two regions that are carbon sequesters are the largest users of forest timber for higher value uses, helping to validate the hypothesis that industrial use of wood for high value actually results in more and better forests over time than lack of industrial use for wood.

Figure 2 shows that, in regions (such as Africa, South America, and parts of South Asia) where wood is harvested chiefly for non-industrial uses (including fuel, cooking, heating, and charcoal production), the data indicate that open forests have been marginalized, not sustained. As Ince writes, "On the other hand, high levels of industrial timber utilization and forest product output in North America and Europe have helped sustain timber supply and demand; averting systematic deforestation… the global forest data clearly support an alternative hypothesis, that forest products and industrial

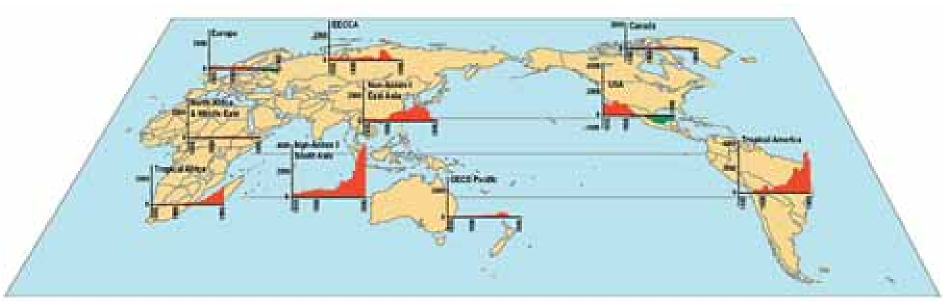

Fig. 1: Historical forest carbon balance ($MtCO_2$) per region, 1855-2000. Notes: green = sink. EECCA = Countries of Eastern Europe, the Caucasus and Central Asia. Data averaged per 5-year period, year marks starting year of period. [Fig. 9.2 from *Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007*, used with permission.]

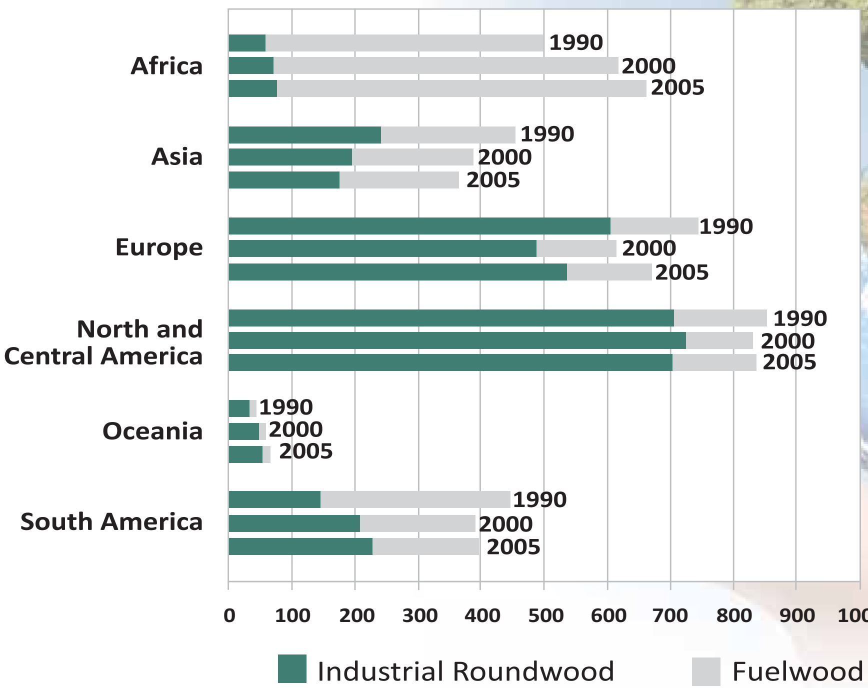

Fig. 2: Global Wood Removal from forests, 1990, 2000, 2005; compiled from FAO data, 2006. [Source: Peter Ince, from *Sustainable Development in the Forest Products Industry*, R. M. Rowell, F. Caldeira, and J. K. Rowell (eds).]

round wood demands provide the revenue and policy incentives to support sustainable forest management, and in turn industrial timber harvest and economical forest management help avoid large-scale systematic deforestation."

At BDC, we have seen that creation of higher value uses of the biomass from local sources (or better utilization of the whole tree) has led to an immediate improvement in the management of forests, crops, or residuals. During one recent BDC tour of a cellulosic ethanol plant in the Midwest, we learned that clearing agricultural residue for industrial use resulted in healthier soil, which led to improved yields and less crop disease. The next step in that carefully- and well-managed supply chain is to determine if the annual use of herbicides and fungicides can be reduced.

These observations and others lead toward a conclusion that the future direction of biomass product technology (including wood energy and biorefining technology) and supportive forest policies will largely determine economic sustainability of forests and forest management. If future technology demands generate sufficiently high values for biomass as a raw material, sustainability will improve. On the other hand, if the average value of biomass is marginalized or cheapened by demands for only low-cost energy or by insufficient forest product technology development to remain economically viable, then historical experience suggests that biomass management may face significant challenges regarding sustainability.

The key learning is that successful research, development, and deployment of higher value products from biomass will drive biomass sustainability. This could potentially have more worldwide importance than policies of a few nations, even if they have good sustainability.

THE 'ADVANCED FUELS' REALITY

Real and significant progress is being made in advanced fuels and chemicals. For our purposes, "advanced" will mean existing bioproducts like ethanol and diesel made from renewable materials like cellulose, hemicellulose, and lignin (biomass.) It also means advanced chemicals like succinic acid and butanol are made from corn, vegetable oil, or cellulosic processes because of the advanced technology.

We have successes to point to. In the list here, we selected a dozen of the older technologies that have good scale-up history. Worldwide, there are more than 100 choices. Some newer technologies use cheaper raw materials or produce higher value products.

- POET makes about 20 million gpy of cellulosic ethanol in Iowa from corn stover (stalks and cobs).
- DuPont is starting up a 25 million gpy cellulosic ethanol plant in Iowa. Raw material is corn stover.

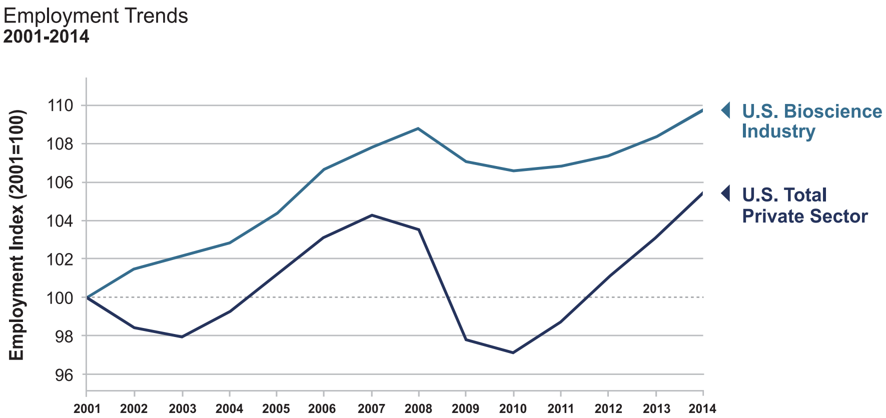

Fig. 3: TEConomy Partners analysis of US Bureau of Labor statistics, QCEQ data, enhanced file from IMPLAN Group.

- Green Biologics (headquartered in Oxfordshire, UK) makes about 20 million gpy of n-butanol from corn in Minnesota. A future facility will use biomass.
- GEVO is making 7 million gpy of isobutanol from corn in Minnesota and will expand to 20 million gpy.
- NatureWorks (a Cargill spinoff) makes about 140,000 metric tons of lactic acid (converted to PLA polymers) in Nebraska from corn.
- Amyris makes about 2 million gpy of farnesene in Brazil from bagasse.
- Beta Renewables makes about 12 million gpy of cellulose ethanol from grain in Italy.
- GranBio is making about 21 million gpy of cellulosic ethanol from bagasse in Brazil using the Beta Renewables technology.
- Enerkem is making about 10 million gallons of biomethanol from sorted municipal solid waste in Canada.
- BioAmber is making 17,000 tpy of succinic acid from corn in France and has just started a 30,000 tpy plant in Canada.
- Borregaard LignoTech is making about 0.5 million tpy of lignosulfonate in several locations around the world. The facility at Rayonier in Fernanda Beach, FL is the latest capacity addition.
- Licella/Canfor have announced a project to make 20 million gpy of biocrude oil in Canada from mill and forest wastes using a catalytic-liquefication process.
- Ensyn operates six commercial RTP plants producing renewable chemicals, heating fuels and refinery feedstocks, including their 3 million gpy Ontario facility. Expansion projects include a 10 million gpy plant in Quebec and 20 million gpy plants in Vienna, Georgia and Aracruz, Brazil.

Progress has been slower than anticipated by the 2007 Energy Independence and Security Act. There have been significant failures, such as Choren in Germany and KiOR in the US. Yet the success of any group of facilities is not as important as the cumulative knowledge from first- and second-generation facilities. The key drivers of the emerging biorefinery industry are the accumulated knowledge and market penetration from all sources and the growing need to make more value-added products from incoming raw materials.

There is already enough data to predict that, within a few decades, the profit from fuels and chemicals will exceed the value of pulp or paper in existing mills. This will add jobs to the mills and jobs for the growth and harvest of additional biomass. In the report "The Value of Bioscience Innovation in Growing Jobs and Improving Quality of Life" (available for download at teconomypartners.com), the authors note that in 2014, the industry employed 1.66 million (Fig. 3.) We expect that biorefineries are likely to create more jobs than the average existing industry.

The more we learn about producing advanced bioproducts, the more value we can obtain from our forest resources. The more value our forests provide, the more sustainably they will be managed. This is a beneficial cycle that we feel is already transforming our industry.

Masood Akhtar is president, Harry Seamans is an operating officer, and Ben Thorp is vice president of the Biorenewable Deployment Consortium. The BDC's mission is to accelerate deployment of economic bioprocess operations by connecting emerging technology with forest industry partners. Learn more at www.biorenewabledc.org.