

# Forest Biorefinery Could Open Door To Bright Future for P&P Industry

Second of two-part series explores goals, progress, and potential financial benefits of the forest biorefinery platform in the paper industry's Agenda 2020 program. — BY BEN THORP AND DEL RAYMOND

The first part of this series in September issue of PaperAge examined the six platforms of Agenda 2020 and the goals and progress being achieved in each. The second half of this series in this issue looks specifically at the forest biorefinery platform and its promises and progress to date.

As shown in Figure 1, the forest biorefinery platform consists of three parts—sustainable forestry, extraction of value from wood prior to pulping, and creation of new value streams from residuals and spent pulping liquors. The discussion below looks specifically at the last two parts of the forest biorefinery platform, examining how today's existing technologies can (and in many cases will) be modified and adapted for use in new and different ways to achieve the many benefits of forest biorefining.

## Value Prior to Pulping

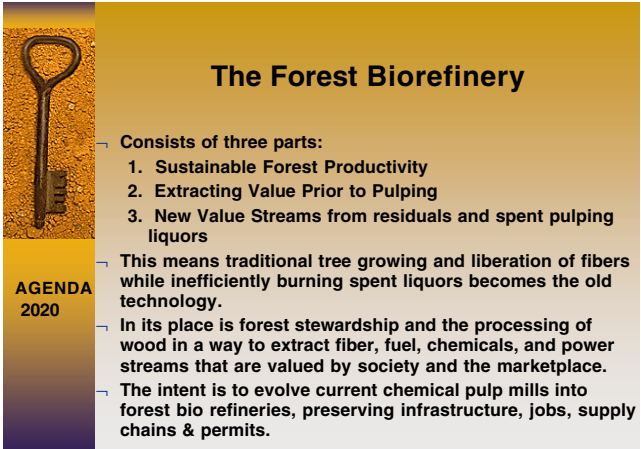
Figure 2 describes the process of extracting hemi-cellulose. This does not impact the cellulose or yield as we currently destroy this hemi-cellulose in pulping. Adding this step is predicted to lower the energy consumption in subsequent operations.

As will be seen later, this can add \$3.3 billion in annual net cash flow increase. It is doable with technology that is already developed. In fact, selected mills have made alcohol for decades. The uniqueness is in applying this to the kraft process, removing the acetic acid, and using newly developed enzymes to accelerate fermentation. It is important to note that *this process does not require gasification*.

Basically, there are two choices for increasing the value from spent liquor - power and fuel/chemicals. For each choice, there is - An incremental capital analysis, and full capital analysis.

Currently, both choices require gasification of black liquor. Black liquor gasification is becoming commercial. The Chemrec atmospheric gasifier has been running continuously for more than a year at Weyerhaeuser, New Bern. The TRI Steam Reformer is in startup at Georgia Pacific, Big Island. A third unit, the TRI Steam Reformer at NorAm Pac in Trenton, Ontario, is in the advanced stages of startup.

Figure 3 shows the process for producing power from hydrogen rich "off gas." This can be run through a gas turbine to generate power and the turbine exhaust gas run through a heat recovery cycle to produce steam for the mill.



**The Forest Biorefinery**

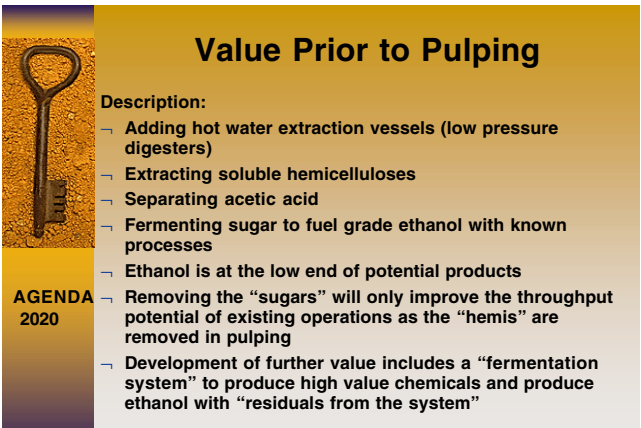
Consists of three parts:

1. Sustainable Forest Productivity
2. Extracting Value Prior to Pulping
3. New Value Streams from residuals and spent pulping liquors

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- This means traditional tree growing and liberation of fibers while inefficiently burning spent liquors becomes the old technology.
- In its place is forest stewardship and the processing of wood in a way to extract fiber, fuel, chemicals, and power streams that are valued by society and the marketplace.
- The intent is to evolve current chemical pulp mills into forest bio refineries, preserving infrastructure, jobs, supply chains & permits.

Figure 1. Forest biorefinery technologies will have a disruptive but potentially positive impact on the pulp and paper industry.



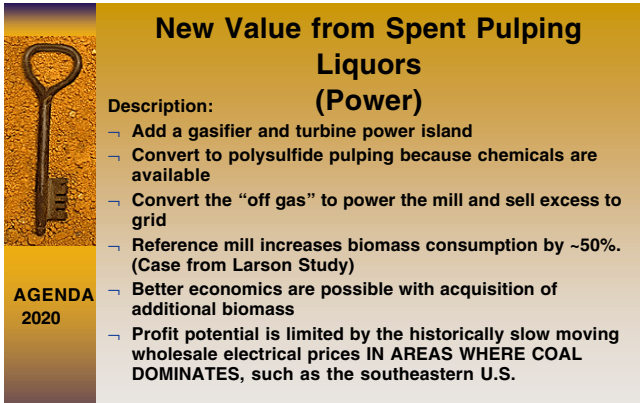
**Value Prior to Pulping**

Description:

- Adding hot water extraction vessels (low pressure digesters)
- Extracting soluble hemicelluloses
- Separating acetic acid
- Fermenting sugar to fuel grade ethanol with known processes
- Ethanol is at the low end of potential products
- Removing the "sugars" will only improve the throughput potential of existing operations as the "hemis" are removed in pulping
- Development of further value includes a "fermentation system" to produce high value chemicals and produce ethanol with "residuals from the system"

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Figure 2. Process of extracting additional value of wood raw materials prior to pulping.



**New Value from Spent Pulping Liquors (Power)**

Description:

- Add a gasifier and turbine power island
- Convert to polysulfide pulping because chemicals are available
- Convert the "off gas" to power the mill and sell excess to grid
- Reference mill increases biomass consumption by ~50%. (Case from Larson Study)
- Better economics are possible with acquisition of additional biomass
- Profit potential is limited by the historically slow moving wholesale electrical prices IN AREAS WHERE COAL DOMINATES, such as the southeastern U.S.

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Figure 3. Producing power from off-gas using conventional technologies.

### New Value from Spent Pulping Liquors (Fuel)

**Description:**

- ▬ Install a black liquor gasifier
- ▬ Add a Fischer Tropsch unit and convert all the BLG off gases to Renewable Fischer Tropsch Fuel (RFTF) for sales to the petrochemical industry
- ▬ Convert the old chemical recovery unit to a biomass boiler
- ▬ Procure additional biomass to run the mill and install a condensing turbine to convert excess steam into power
- ▬ This is a very rough way to configure a mill
- ▬ Higher values can be obtained by configuring a mill with a proper steam/electrical balance and by adding distillation columns to produce fuels (versus basestock)

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Figure 4. Alternate power production by converting BLG off gases to RFTF

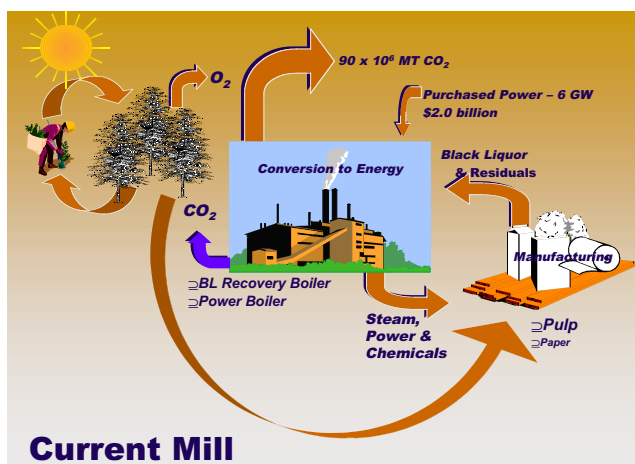


Figure 5. Typical pulp mill today using conventional technology

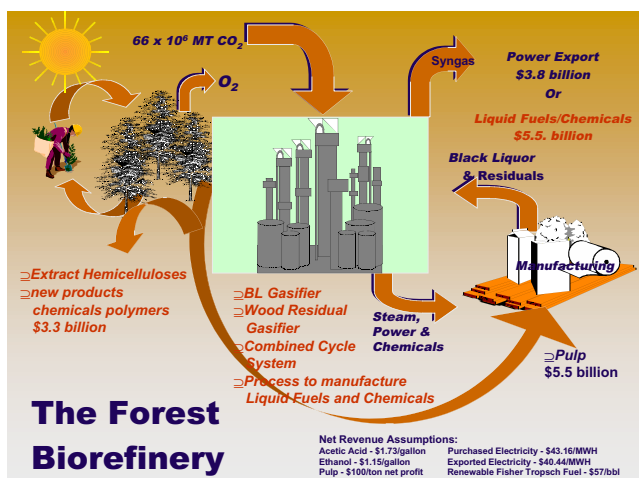


Figure 6. Same mill converted to a forest biorefinery operation

The processes after cleanup of the off gases is conventional and gas turbines are used in many mills throughout the world.

Here the hurdle is economics rather than technology. To justify this approach, the recovery boiler has to be near the end of its useful life, the mill viable enough to justify replacement, and the wholesale electric price at or greater than about \$50/MW hour. DOE has co-sponsored an engi-

neering study complete with steam and power balances, market analysis, and engineered capital cost estimates. Copies of the *Larson Study* are available on request.

Figure 4 shows an alternate with a national market verses the regional market for power. This alternate is to gasify the black liquor and put the off gas through a Fischer Tropsch Process to generate a multi molecular weight, *renewable* feedstock that is more valuable than crude.

The Fischer Tropsch process will be new to the forest products industry. However, it is used in other industries and is commercially available. The renewable feedstock is commonly known as RFTF (Renewable Fischer Tropsch Fuel). The economics appear to be much better than the typical power case. However, with current technology, the recovery boiler needs to be at the end of its useful life and the mill sufficiently viable to warrant replacement. An engineering study is currently being conducted to confirm or change the assumptions made.


The fact that the recover boilers need to be at the end of their useful life for complete economic justification is both a problem and a potential blessing. The problem is that it could take a couple of decades to replace our aging fleet of recovery boilers. The potential blessing is that we have an aging fleet that is about 30 years ahead of the current large tropical hardwood mills. This gives the U.S. a potential 30-year economic lead. Further, we know that a more valuable stream of more highly valued chemicals can be produced. It will be up to future generations to advance the technology to maintain a competitive advantage.

Figure 5 is a "picture gram" of a current pulp mill with conventional technology. This figure shows consumption for the U.S. kraft industry.

Figure 6 is the same mill that has evolved to a forest biorefinery. Again, national consumption and production figures are shown. The estimated net cash flow from the ~50 million annual tons is estimated to be \$5.5 billion or about \$100 per ton. This is probably higher than most U.S. mills have experienced in the past five years.

The net cash flow from the 1.9 billion gallons of ethanol and 600 million gallons of acetic acid produced from fermenting hemi-cellulose is \$3.3 billion. The annual net cash flow from sale of the RFTF can be as much as \$5.5 billion. Together they total \$8.8 billion or 160% of the historical net cash flow derived from pulp. Further, we know that more valuable chemicals can and will be produced. More importantly, this is just from one of the six technical platforms. This is why the agenda 2020 goal of doubling net cash flow may prove to be conservative.

Figure 7 lists some of the major hurdles. Again, the greatest challenge is not the development of technology, but rather the lack of technical entrepreneurship. The question is: can we develop this skill as rapidly as it will be needed?



## Major Hurdles

- Lack of industry capital
- Historical lack of technical entrepreneurship/leadership
- Detailed process studies and cost estimates for first & third cases
- Assembling a technical needs pathways and a strategy for DOE funding to include:
  - Refractory
  - Materials selection
  - Bed fluidization and uniformity (LTG)
  - Hot gas cleanup (for cases 2 and 3)
  - Integration into existing mill systems
- Assembling a compelling case
- Recruiting a consortium
- Identifying a mill or mills that meet “host” criteria

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Figure 7. Challenges and hurdles in implementing forest biorefinery technologies

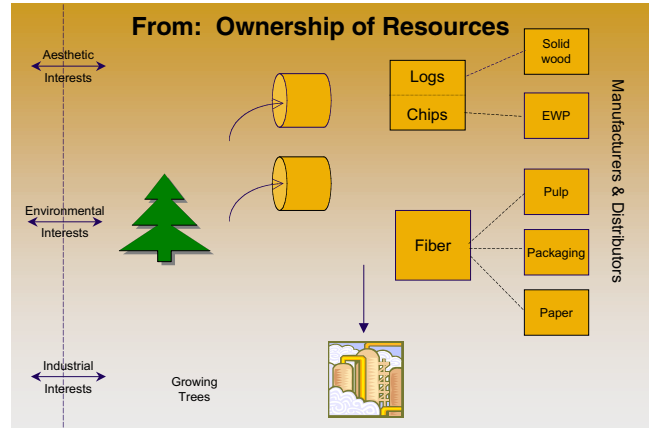



Figure 9. Historical ownership-based business model of pulp and paper industry



## Conclusion

- There is a unique opportunity in the U.S.
- We reside in the world’s largest and most demanding marketplace
- All our products are made from renewable resources
- We can customize or develop improved products for the demanding marketplace and renewable fuels for the benefit of the nation and society
- Our aging mills turn out to be another asset. The return on assets favor installing much of the technology as recovery boilers reach the end of their useful life. Our aging fleet of boilers can give us a 30-year competitive advantage over newer tropical pulp mills.
- Our fate is in our hands
- The name of the game is DEPLOYMENT

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Figure 8. Conclusions from years of experience and various perspectives

Figure 8 shows major conclusions based on more than a decade of Agenda 2020 experience and many years in the pulp and paper industry as well as the academic side, the supplier side, the engineer/construction side, and the owners side. Three points need emphasis:

- First, we have unique opportunity at our doorstep
- Second, our fate is in our hands
- Third, the name of the game is deployment, not wait and watch.

There are several ways of getting involved and becoming part of the solution:

- Recognize your mill must change or be a candidate for overseas replacement
- Learn more about Agenda 2020 and its projects
  - Contact your company representative
  - Join a committee
  - Find out which programs will benefit your mill
  - Find out if state/federal funding is available
  - Learn how to successfully deploy new technology while minimizing risk to operations
  - Help create a plan to change your mill or your company both short and long range.

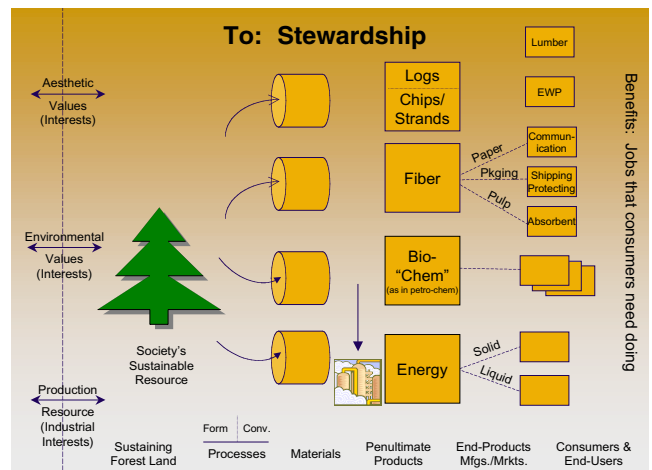


Figure 10. Business model from a new perspective of stewardship

Figure 9 is a depiction of the historical business model that was developed at Agenda 2020’s second technical symposium held in March of this year. It depicts the forest products industry as growing trees and producing logs, chips, and fiber from them. These were converted into conventional products and sold largely through distributors. This industry was “distant” from its customers and from those who also used and loved the forests.

Figure 10 is a depiction of stewardship of resources, be they owned or purchased. Products now include bio-chemicals and energy. Trees are more important and effluents are considerable smaller. There is a greater focus on customers. Products are defined in terms of jobs that customers need doing. Many of these customers are those who use and love the forests. So this picture “wraps” in a very healthy way. ■

*About the Authors:*

**Ben Thorp** is recently retired Agenda 2020 Deployment Director for Georgia-Pacific Corp. He currently provides strategic consulting to the pulp and paper industry (bathorp@comcast.net). **Dr. Raymond** is Director of Strategic Energy Alternatives at Weyerhaeuser and Chairman of AF&PA’s Chief Technology Officers Agenda 2020.