Encouraging the development of biorefineries - development of qualitative and quantitative planning models

John L. Jechura*, Kelly N. Ibsen, James D. McMillan, Keith B. Neeves
National Renewable Energy Laboratory, 1617 Cole Boulevard, Golden, CO 80401-3393
Fax: 303-384-6827; john_jechura@nrel.gov

The National Renewable Energy Laboratory (NREL) has a history of funding research to develop technology to convert biomass to usable fuels and chemicals. The major emphasis has been the production of fuel-grade ethanol. By-products have primarily been limited to power generated from process waste, such as produced lignin. This type of process approach has a major economic disadvantage: all production costs have to be recovered by a single major product, ethanol, and a small number of minor products. This limits the flexibility of the processing plant to recover investment and operating costs and to return a profit to investors.

This approach for a biomass processing plant is quite different from an analogous fuel processing plant, a petroleum refinery. A modern petroleum refinery produces multiple products. Its processing units give the modern petroleum refinery flexibility to separate, chemically react, and blend internal streams based upon contractual requirements and local economics. Gasoline may be a major product but it is not the only product. In addition, feedstocks are not considered equal in value — it may be economical for some feedstocks to give high yields of gasoline, but for others it may be more economic to give other products, such as diesel and heating oil, asphalt, or coke. The decision as to which is more profitable is made based on local economics, price of competing feedstocks, and contractual production agreements. A key operating strategy is that non-gasoline streams are treated as marketable commodities.

The Department of Energy's Biofuels program is investigating potential co-products from the biomass to ethanol process. These co-products would provide revenue sources from markets other than fuels. Producing several co-products would make the biomass processing plant to be more of a "biorefinery" than just an ethanol production plant. It is envisioned that the slate of products would include fuel (ethanol), power (combustion or gasification), and one or more chemicals. This approach aligns with the recent focus on increasing biobased products in the US markets.

Some of these projects focus on how to chemically convert intermediate species to more valuable products (such as the conversion of lignin to simpler phenolic or aromatic materials). Other projects focus on how to economically separator chemical species that are present in the existing intermediate streams (such as the separation of sugars from hemicellulose hydrolyzate liquid).

One definition of a refinery could be that there are options on how to process intermediate streams to create two or more products. In a petroleum refinery, decisions must be made as to how to process intermediate streams that could go to gasoline or to some other product. Creating the other products would decrease the amount of gasoline produced, but there may be economic justification to do so. In a biorefinery, the choice would be to further process intermediate streams to ethanol or some other product, knowing that the production of the other products would decrease the amount of ethanol ultimately produced.

Two recent projects have focused on the larger picture of the planning and operation of a biorefinery:

?? *"Qualitative" Biorefinery Modeling Effort.* Analyze a biorefinery scenario to develop scenarios for a slate of products that have higher or lower selling prices than ethanol and determine the effect on the ethanol production cost.

?? *"Quanitative" Biorefinery Modeling Effort.* The objective of this agreement is to develop computer software to easily compare various product slates from a biorefinery and the necessary process configurations to find optimum configurations based upon market conditions.

The Qualitative Biorefinery Modeling Effort will help to identify optional products that could be produced from the intermediate streams of a biomass processing plant. Some of the products may be of higher value than ethanol and would justify higher processing costs. Other products may be of lower value but could be produced at a lower cost. Overall, a good mix of ethanol and other products could increase the profitability of a biorefinery.

Once product choices have been identified, then a tool is necessary to evaluate what are the most cost effective mix of products. This is the role of the software product that is the result of the Quantitative Biorefinery Modeling Effort. This software product is analogous to the linear programming tools used in petroleum refineries to plan a refinery and schedule their operations.

Subcontracts for the Qualitative and Quantitative Biorefinery Modeling efforts were placed in mid 2001. The results of the work will be presented.