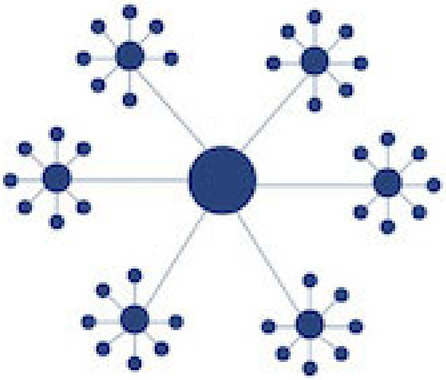
Two-Step Biofuels Technologies Super-Refineries



By JIM LANE, *Biofuels Digest*

Imagine, for a moment, a biorefinery as large as an oil refinery — competing on equivalent scales, gaining comparable economic and tax incentives such as accelerated depreciation.

The problem? The impossibly high cost of sourcing sufficient biomass within, say, a 50-mile radius. After 50 miles or so — a little less, if small trucks are used, a little more if barges or rail are used — the economics of transporting raw biomass become impossible. Too much oxygen, too much water — the weight is a killer.

That's one of the primary reasons why refineries in the bio-space rarely exceed 25 million gallons for projects based on agricultural residues, 50 million gallons for woody biomass, and 250 million gallons for waste or crop-based oils.

In turn, it's a reason why biofuels have challenges in competing with fossil fuels on a gallon-for-gallon basis. It's one of the reasons why technologies are so attractive when they focus on the production of dense supplies of raw material — for example, algae biofuels projects or solar fuels of the type that Joule is scaling up.

**Solutions for the aggregation challenge**

The dandelion's hub and spoke system

An interesting work-around that has gained currency in recent years has been the production of biofuels in what transport mavens call the hub-and-spoke system. But nature gives us a living example — the dandelion.

In these scenarios, smaller biomass projects manufacture refinery intermediates rather than finished fuels. They are then shipped in a highly densified form to massive refineries where they are converted to finished fuels and chemicals.

It’s been discussed for a long-time with, for example, pyrolysis oils and biocrudes. No two of the companies making these intermediates — for example, KiOR, Ensyn or Dynamotive, make exactly the same product.

But they share four characteristics: their outputs cannot be used directly as transportation fuels, they can be quite inexpensive to manufacture, they work well with multiple feedstocks, and they can be supplied to refineries for upgrading.

How dense is dense?

Corn stover in its natural (wet) state has around 5500 BTUs per pound. Crude oil has around three times that value, and bio-oils generally fall around the mid-point between the two. Now, you can transport corn stover, as mentioned, around 50 miles before it becomes uneconomical. But, as any student of the Gulf of Mexico’s geography knows, you can transport $90 crude oil across hundreds of miles of Gulf and the economics work very well.

How far do you need to transport biomass to make a super-refinery. Well, if you can support of 25 million gallon cellulosic biomass project over, say, a 50 mile radius — then a 500 mile radius would support a 2.5 billion gallon project. Densify the production of biomass by producing, say, high-volume energy crops or algae biomass — and that’s the kind of scenario that could result in a million barrel per day biorefinery.

The gasification challenge

One of the barriers to such a technology is simply the ability to effectively gasify bio-oil, in a refinery setting, into a workable syngas that can be catalytically converted into fuels and chemicals. And to prove out that the two-step process can work, economically — given that you have to pour in heat to make bio-oil, then heat it all over again in a refinery setting.

The Iowa State Project

To answer those questions, the DOE launched a two-year, $1 million project with Iowa State University — and the Iowa Energy Center chipped in $450,000 over three years.

Mike Krapfl, at Iowa State, writes:

In the Iowa State project, biomass is fed into a fast pyrolysis machine where it’s quickly heated without oxygen. The resulting bio-oil is sprayed into the top of the gasifier where heat and pressure vaporize it to produce a combination of (mostly) hydrogen and carbon monoxide that’s called synthesis gas.

The bio-oil gasifier has been fully operational since June and has been converting bio-oil made from pine wood into synthesis gas. As the project moves beyond its startup phase, researchers will use bio-oil produced by Iowa State researchers and fast pyrolysis equipment.

Song-Charng Kong, an associate professor of mechanical engineering who’s leading the latter project, will build a computer simulation model of bio-oil gasification. The model will take into account changes in temperature, pressure and biomass. It will allow researchers to understand, predict and ultimately improve the gasification process.

The project will also develop a systems simulation tool that allows researchers to examine the technical, economic and big picture implications of bio-oil gasification. And finally, the project will develop a virtual reality model of a full-size plant that will allow researchers to see, study and improve a plant before construction crews are ever hired.

“The physics and chemistry will be behind all these models and images,” Kong said. “This is a very new area to study. We can use these models as a tool to understand what will happen as this technology is scaled up.”

“We hope to be able to use cellulosic biomass as opposed to using corn grain for the production of fuels,” said Robert C. Brown, the director of Iowa State’s Bioeconomy Institute, an Anson Marston Distinguished Professor in Engineering and the Gary and Donna Hoover Chair in Mechanical Engineering. “This helps us move toward cellulosic biofuels.”

The economics

On the BTUs, to compete with crude oil, pyro oils are going to have to have comparable costs for processing, and a price of around $60 per barrel. And, the likely targets for production are not going to be the C1 through C4 molecules where natural gas is going to have a sustainable advantage for some time to come — except where gas is unavailable, or renewable attributes have some premium value.

The super-refinery, home to technologies from many companies

There’s something very compelling about the idea of super-refineries — that license a variety of processes to convert syngas into high-value fuels and chemicals. For example, syngas fermentation technology from the likes of INEOS Bio, LanzaTech or Coskata. Or, more conventional catalysis technologies from the likes of Rentech.

More work is needed to understand the optimal balance in a two-step system. How small can the technology for pyrolyizing biomass really get — community-based or regional? How big can a bio-oil upgrading refinery become — regional or super-regional. And where might such a refinery be placed — perhaps, for example, down the Mississippi from the farm belt?

The bottom line

Hub and spoke is a compelling model. It’s early days in the development of such a model. But it is an intriguing idea that a rural community could collect and pyrolize its biomass, barge or rail it down to a super-refinery, and receive a stream of fuels and chemicals in return with which to power a local economy based on low-cost energy.

That might make a very solid model for how the Midwest — or other agricultural regions around the world — will obtain their transportation fuels in the future.

What’s your take? Please feel free to comment below!