Who, What & When Of Cellulosic Ethanol Commercialization

Jim Lane, Biofuels Digest

The old saying is that "cellulosic ethanol is always and forever five years away." If thats true, then its time to party like its 2014, because commercial-scale cellulosic ethanol is just now upon us.

Companies that have been in the R&D phases for years - if not decades - are emerging with a set of technologies, and partners with strong balance sheets, that have every chance of making the 2010s the "Decade of Cellulose".

In many ways, with solar and energy storage technologies still in the R&D or small commercial phase - biomass represents that "shovel-ready", "fire when ready" technology for short-term reductions in fossil fuel intensity.

Key Technologies:

Enzymatic Hydrolysis

Most of the major early players have opted for this route - Inbicon, POET, Mascoma, Abengoa and Verenium prominently among them. There are three-step and two step versions of the process. In the three-step process, the biomass is pre-treated with harsh chemicals to soften the bonds with which the hemicellulose is held together â€“ a process not completely foreign to pulp & paper pre-treatment. (Expect that the development of pre-treatment processes using renewables, or resulting in higher yields, will be an area of increasing focus by specialist companies).

In the second "magic" step, enzymes are used to hydrolyze C5 (xylose) and C6 (glucose) sugars from hemicellulose. From there, sugars can be fermented into ethanol. POET, Abengoa and Verenium are among the companies pursuing this process.

In the two-step version of the process, "magic bugs" â€“ consolidated bioprocessing organisms directly convert pre-treated cellulose into ethanol rather than sugars. Qteros and Mascoma are among companies pursuing this route.

Acid Hydrolysis

An older process - originally developed in the First World War, uses weak sulphuric acids to hydrolize the cellulose. Traditional yields - 18-50 gallons per on of dry biomass - made the process useful oinly in cases of sever shortages of fossil fuels, such as wartime emergencies. But companies such as Agresti and BlueFire Ethanol have optimized yields into the 50-80 gallons per ton range, making the process

economically viable with ultra low-cost feedstocks such as municipal solid waste (MSW) where "tipping fees" for disposing of waste can be captured, in addition to the value of the ethanol.

Gasification

A more exotic route is gasification, in which the biomass is heated until it forms a syngas of hydrogen and carbon monoxides - catalysts are introduced during the cooling process that convert the syngas into ethanol (or other feusl or chemicals). Range Fuels and Coskata are among companies developing this technology.

Hybrids

ZeaChem is pursuing a hybrid strategy â€“ converting sugars to ethanol with an acetogenic process that does not produce CO2 as a by-product - good for emissions, also good for efficiencies. In addition, the lignin residues are gasified to provide extra hydrogen to make the process even more chemically efficient.

Feedstocks

Cheap sugars are the mothers milk of all cellulosic ethanol processes. Residues - agricultural, forest, animal or municipal wastes are one source, and are the heart of the POET, Mascoma, Range Fuels, Abengoa, Agresti, Verenium and BlueFire are among those focusing on waste. The other route: dedicated, high yield "energy crops" such as energy cane, poplar, miscanthus or switchgrass. Ceres is one company focusing on feedstock development, while ZeaChem is focused on high-yield poplar stands.

Yields & ROI

Generally speaking, cellulosic ethanol is proving expensive in terms of upfront capital. Costs of $4-$8 per gallon of installed capacity are typical, even at commercial-scale.

Yields vary depending on the process. Acid hydrolysis is generally in the 40-70 gallons per ton range. At the high end, ZeaChems process has a projected production yield of 135 gallons per ton. Gasification and enzymatic hydrolysis have yields in the 70-110 gallons per ton range.

Overall cost, however, is more encouraging. Projected production costs per gallon range as low as $1 per gallon (Coskata) â€“ and generally speaking, cellulosic ethanol is expected to be competitive on per gallon cost with $60-$100 oil. However, gasoline engines are not generally designed around ethanols attributes â€“ lower BTUs, higher octane - E85 ethanol generally delivers 20-25 percent lower mileage in a flex-fuel engine. Ethanol injection engines deliver up to 15 percent higher mileage than standard gasoline engines, but they are not yet available in production models. Overall, ethanol will have to come to the market at $1.95 per

gallon or less to be competitive with $100 oil; at todays prices (around $75-$80 oil), ethanol production costs will have to come in at around $1.50 per gallon to be competitive on a miles per dollar basis.

Commercialization Timeline

For the early 2010s, the volumes will be small - but in so many ways its important to see the pace of commercialization as a product of nefarious economic times as much as a product of the technology timelines. Here are some highlights to look out for in 2010-2012.

2009: Inbicon has opened its 1.4 Mgy wheat straw ethanol demonstration plant in Kalundborg, Denmark. KL Energy is operating a 3 Mgy commercial facility in South Dakota, while several pre-commercial plants are operating in the 20,000 â€“ 1 Mgy range in the US, operated by Coskata, Mascoma and Verenium, among others. ZeaChem will commence construction of its demonstration plant this year.

2010. Verenium will break ground on a 36 Mgy plant in Florida. Range Fuels will commence production at its 25 Mgy Soperton Plant in Q2.

2011. INEOS Bio will commence production at its first commercial scale facility by year end â€“ capacity not yet disclosed. Iogen is expecting to commence production at its the 23 Mgy plant north of Saskatoon by year end, using wheat straw and other cellulose as feedstock. POETs 25 Mgy Project LIBERTY plant in Emmetsburg, Iowa is expected to open by year end, using corn cobs as feedstock. BlueFire and Abengoas demonstration plants are projected to open in Lancaster, CA and Hugoton, KS by year end.

2012. Verniums 36 Mgy plant projected to open in Florida. Coskata is expecting to open its first 50-60 Mgy plant in the US Southeast by year end. Mascoma expects to open its 20 Mgy cellulosic ethanol demonstration scale plant in Kinross, Michigan in September. KL Energy is aiming to open five 12-25 Mgy plants by mid-year â€“ at locations on three continents.

2013. BP said that it will commence production of cellulosic ethanol from biomass in Brazil in 2013.

Elsewhere Around The World

Though cellulosic ethanol efforts are still in the research phase in other countries, notable work is underway. Praj Industries has a major R&D effort underway in India while Mission New Energy is investigating jatropha waste as a CE feedstock. Petrobras has a unit developing ethanol from bagasse in Brazil. Australia has a government and industry-sponsored research effort underway. In Europe, Novozymes, Danisco and Syngenta are supporting major efforts to develop cellulosic ethanol, while DSM White has a research effort under way for a to drastically reduce the cost enzymes for the hydrolysis of lignocellulosic biomass. DSM conducts this project in collaboration with its partners Abengoa Bioenergy, the Los Alamos National Laboratory, and the Sandia National Laboratory.