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Alternative Energy - Alternative Fuels and Chemicals: Industry Tidbit

Gen2 Biofuel Feedstocks: The Coming Surge in Energy Crops and Cellulosic Sugars

As energy investors know well, it is much better to own the oil than to refine it. In other words, the bulk of the value is in the upstream of the value chain. Next-generation (Gen2) biofuels and renewable chemicals have a somewhat different market dynamic – there is considerable value in the proprietary IP for processing – but feedstock providers can nonetheless capture a sizable share of the economics. With this in mind, following recent channel checks and in the context of our Gen2 coverage, in this report we highlight the addressable market for two subsets of Gen2 biofuel feedstocks: energy crops and cellulosic sugars.

The rationale for energy crops. Because cellulosic biomass is a non-food material that has little or no intrinsic value, the cost structure for Gen2 biofuels using these feedstocks is immune to day-to-day volatility in the agricultural market. Cellulosic biomass, however, is not without its constraints. Current sources of biomass, such as forestry residue (wood chips, etc.) and agricultural waste (corn stover, sugarcane bagasse, etc.), are typically limited in scale. For example, even in such biomass-rich areas as the U.S. Southeast, where wood chips are plentiful, their availability within a reasonable radius from a biofuel plant is often constrained. This helps explain why cellulosic biofuel plants (such as KiOR's biocrude plants) are typically being designed with much lower production capacity than modern corn ethanol plants: 20-40 million gallons vs. 100+ million gallons. In addition, these sources of biomass are byproducts derived from other processes and are, therefore, subject to supply disruptions.

In contrast to cellulosic biomass, dedicated energy crops are specifically designed to be used in biofuel applications. Energy crops offer five key advantages: (1) high yield density: increasing crop yields per acre shortens the collection radius for biofuel plants; (2) high net energy balance: compared to corn (and, to a lesser extent, sugarcane), energy crops need less energy input per unit of energy output; (3) low input requirements: reduced water and fertilizer needs are a key source of savings; (4) ability to grow on marginal land: energy crops can grow in a broad range of environments, including those not well-suited for most food crops; and (5) customization potential: energy crops have the potential to be tailored for specific production and refining processes. On a side note: above and beyond biofuels, energy crops can also be well-suited for use in biomass-based power generation.


Source: ActionAid

Types of energy crops. Most plants that can serve as energy crops are already used commercially in their natural form, but a key aspect of energy crops is that they are specially tailored (via genetic modification or otherwise) for biofuel applications. The optimal crop for any given biofuel project can depend on (1) the specific end product and (2) geography and climate patterns, though the latter – as noted above – is often flexible. Here are some examples. Jatropha, a source of oil (in place of soybean or palm oil) for production of renewable diesel and jet fuel, is a drought-resistant perennial that is especially well suited for Central/South America, where it is a native crop. SG Biofuels is working to develop jatropha in Guatemala and Brazil, though potential opportunities exist across the Southern Hemisphere. (The adjacent photo shows jatropha in Kenya.) SG Biofuels notes that its best cultivars can currently produce crude jatropha oil for $1.40/gal, and the long-term target is $0.75/gal. Sorghum – the sweet variety for conventional ethanol plants and the high-biomass variety for cellulosic ethanol plants – is capable of growing on ~80% of the world's agricultural lands, with some developers focusing on the U.S. market (e.g., Chromatin) and others on Brazil (e.g., NexSteppe). Miscanthus, a perennial grass that can be used for ethanol, is native to Africa and South Asia; Mendel Biotechnology has been working to develop it domestically, for example, in Ohio on land reclaimed from coal mining by Oxford Resource Partners. It is also possible to engineer energy crops to have internal enzymes, making it easier to break down their cellulose, as Agrivida has done with corn stover and switchgrass.

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The rationale for cellulosic sugars. For fermentation-based Gen2 companies – especially those specializing in renewable chemicals and other high-value end products – sugar is a crucial feedstock. While sugar can obviously be easily produced from sugarcane and some other food crops, cost is clearly a limiting factor amid a global bull market for agricultural commodities. This is why companies such as Amyris and Solazyme (which currently rely on sugarcane) and Gevo (which is using corn) have indicated their desire to eventually shift towards alternative feedstocks – once they become available on a commercial scale. Whereas cellulosic material – either waste biomass or energy crops – can be used directly in thermochemical production of biofuels (e.g., gasification or catalytic processing), for it to be used in fermentation there needs to be an intermediate step. This involves breaking down the cellulose so that the sugar can be extracted. Some biofuel producers take a vertically integrated approach and, therefore, aim to do this in-house. However, there is a small but growing subset of companies that are developing cellulosic sugars for sale to third parties, either via direct product sales or technology licensing.

Production options for cellulosic sugars. The process of converting cellulosic material into fermentable sugars is called saccharification, and it can be performed via several types of hydrolysis. When the material is saccharified, separating the carbohydrates, the sugar is released. The main byproduct, lignin, can be used to provide the energy for the production facility and/or serves as an additional source of revenue. There are three main types of hydrolysis, which we discuss below. To be clear, all three of these are development-stage technologies that have yet to scale up commercially.

- **Acid hydrolysis.** This process entails using acid to break down the cellulose. For example, HCL CleanTech, as its name suggests, aims to use concentrated hydrochloric acid. The company has projected that the cost of its cellulosic sugars will be at least 17% lower than the cost of corn mill sugars. Weyland, based in Norway, estimates that its acid-based process enables 98.5% of the acid input to be recycled, thus creating cost savings. SucreSource, a subsidiary of cellulosic ethanol developer BlueFire Renewables, also uses acid.

- **Enzymatic hydrolysis.** This process uses enzymes, probably the technology that is most commonly associated with cellulosic biofuels. EdeniQ plans to provide sugars via an enzymatic platform as part of a broader suite of services for cellulosic biofuel producers. In addition, of course, plenty of cellulosic biofuel produces are themselves developing enzymatic technology, either wholly in-house or in partnership with enzyme providers (such as Iogen’s collaboration with Codexis). Historically, the downside of enzymes has been their high cost, with Agrivida estimating that they can add $0.50-0.75/gal to the cost of cellulosic biofuels, though next-generation biocatalyst technology helps address the cost issue.

- **Supercritical hydrolysis.** This process, pioneered by Renmatix, uses pressure and heat to bring water to a supercritical state, in which it behaves like both a liquid and a gas. Cellulose becomes soluble in the supercritical fluid, allowing the sugar separation to take place. The company has said that its first commercial facility will be able to produce 100,000 dry tons of sugars each year at a cost that is competitive with Brazilian sugarcane. We already noted that many Gen2 biofuel producers are interested in sourcing cellulosic sugars, and in this context, Amyris has said that it plans to buy Renmatix’s sugars upon commercialization.

Finally, there is one more approach to production of sugars, but this one falls outside the cellulosic arena altogether. Developed by Proterro, this biosynthetic process combines an engineered photosynthetic microorganism with a high-density, modular solid-phase bioreactor to produce sucrose. Instead of breaking down cellulosic biomass, these cellulosic sugars are produced by combining water, carbon dioxide, sunlight, and nutrients.

Company Citations

Company Name	Ticker	Exchange	Currency	Closing Price	RJ Rating	RJ Entity
Amyris, Inc.	AMRS	NASDAQ	$	11.52	1	RJ & Associates
Codexis, Inc.	CDXS	NASDAQ	$	5.44	3	RJ & Associates
Gevo, Inc.	GEVO	NASDAQ	$	5.90	2	RJ & Associates
KiOR, Inc.	KIOR	NASDAQ	$	9.25	2	RJ & Associates
Oxford Resource Partners L.P.	OXF	NYSE	$	17.38	2	RJ & Associates
Solazyme, Inc.	SZYM	NASDAQ	$	11.14	2	RJ & Associates

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