Transformers — Eight Technologies to Rock Bio

JIM LANE, Editor & Publisher, Biofuels Digest

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Game changer, breakthrough, revolution, quantum leap. A lot of technologies arrive on the doorstep wrapped in one of those descriptors or another. Sometimes wrapped in all of them.

But What Technologies Would Really Rock the Bio World?

A number of discoveries are notable, however, by their absence. We see so much innovation in the fuel processing technologies and in the genetics of crops. But what about the platform improvements in feedstock production and harvest?

There is a handful that would have catalytic impact, not only for their investors, but for a host of technologies and companies downstream that would see their fortunes irrevocably improved.

We've named them the Transformers. In some cases, the hunt has been on for some time. In others, there's hardly any activity at all. Let's take a look at eight platform inventions that would turn the bio-based fuels and materials industry upside down.

8. Jatropha Harvester

There's an awful lot of jatropha going into the ground in various parts of the world.

One thing that would make jatropha a lot more economically feasible is a mechanical jatropha harvester. It's not very sexy technology, in so many ways — no synth-bio, no Nobel Prizes in sight, but harvesters are absolutely key to taking any crop from serving a subsistence economy and making it effectively serve an industrial economy. Traditional tree shakers don't get the job done. Lately, BEI says it has developed such a technology and is trialing it now, down in Honduras at the Agroipsa Farm. Here's more on that. [1]

7. 5-Cent Cellulosic Sugars

A bunch of companies are chasing low-cost cellulosic sugars — among them, Proterro, Comet Biorefining and Naturally Scientific. Why 5 cents per pound? Generally, at those prices, cellulosic renewable fuels made from agricultural residues start to really rock — and other fermentation processes, such as those from Solazyme and Gevo — as they are able to train their magic bugs to tolerate the "dirty sugars" — dramatically expanding potential for increasing production capacity at affordable fuel prices. Former U.S. Vice President Thomas Marshall said, "What this country needs is a good 5-cent cigar," but it's a good 5-cent cellulosic sugar that would transform cellulosic conversion technologies from players in the high-value chemicals and feed markets into fuel monsters.

6. Annual 30-Ton-Per-Acre Sustainable Biomass Production.

At 40 tons per acre per year — generally at this time only achievable with a handful of terrestrial plant forms and algae — opens up the potential capacity of systems. Remember, key to making renewable fuels economical is scale, and key to scale is how far you can affordably transport biomass, and how much production land can be sustainably put to work to deliver biomass to a given plant. A 20-square-mile plantation, at those production rates (assuming you can locate all the nutrients), yields 192,000 tons of biomass, enough for example, to supply 50 million gallons of cellulosic ethanol.

Algal growth technologies are, generally, well on the way to making this an everyday reality. 25-grams-per-square-meter-per-day systems equate to about 36 tons of biomass per acre per year, and that's becoming table stakes in algal development. But not everyone can use or grow algae, and that form of biomass has its own set of special challenges. A 30-ton-per-acre sustainably produced wood or terrestrial crop? Game changer.

5. Algae Extraction

While we are on the subject of the special challenges of growing algae, there's the problem of getting the algae out of the water or the water out of the algae. Given that a decent microalgae concentration is around 0.1 percent, you have to remove 1,000 gallons of water per gallon to get a gallon of dry algal biomass, which has about 50,000 BTUs or so. So even if you are expending just a handful of BTUs per gallon to move the water, you're dangerously close to using more energy to produce algal fuels than the fuel contains.

That's why consortia such as the NAABB have made this a high priority, and it ranks near the top of the problem chart in the Algal Technology Roadmap developed by the DOE. Companies such as Solazyme and Aurora Algae say they have proprietary solutions, and companies like OriginOil and AlgaeVenture Technologies have been developing solutions for license. For sure, no algae fuel company will emerge at scale without a solution to this one.

4. Extremophile Sugar Crops

The great news about cheap sugars of the non-cellulosic kind is that there is plenty of land available for growing additional cane in Brazil, Angola, Pakistan or Mozambique. The bad news? That's not generally where the fuel users are, and visions of Africa and Latin America planted with cheap cane for providing fuel to the EU, U.S. or China, smacks to many of a return to colonialism.

So, what's a fuel-starved country from the cold North to do? Develop a sugar crop that thrives in cold climates. In recent years, extremophile species have been the object of increasing attention — we've discovered that understanding how some life can thrive in extreme conditions gives us added options.

Developing plants that can utilize less sunlight and heat without losing productivity (or failing to survive at all) is a key to unlocking the bio-based opportunities in the colder EU and North American climates. Could be a cold-loving cane, or higher-productivity sugar beet or sweet sorghum. Any way you slice it, a solution that competes with Brazilian cane is going to attract huge amounts of attention.

3. Fix Rubisco or Other Aspects of the CO2 Fixation Cycle

A major limiting factor in growing biomass affordable is the cost of transporting the carbon that the plants or microorganisms need. In their ordinary lives, they fix atmospheric carbon. The process doesn't happen nearly fast enough. The key enzyme? RuBisCo. "Biofuels research," we observed in *To Fix Carbon, Food, Energy: Fix RuBisCO*, "while impressive and laudable, is overly focused on midstream processing technologies and not on the key factor: The appallingly low rate at which plants convert sunlight to energy. For example, corn checks in with a 1 to 2 percent efficiency rate. Raise photosynthetic efficiencies to 10 to 12 percent. With such a fix, so many of the concerns about biofuels — cost parity, food vs. fuel, the cost of transporting biomass — begin to melt away.

2. Nitrogen Take-Up

In recent articles, we've written not only about the opportunities in RuBisco, but the increasing scarcity of phosphorus. But what about nitrogen take-up? The rate at which soybeans, for example, can fix atmospheric nitrogen is pretty slow for prime-time biofuels, resulting in productivities under 100 gallons per acre per year. Other terrestrial crops can't even do that and require applications of fertilizer. "In the last 50 years, the nitorgen fertilization of crop plants worldwide has increased more than 20-fold. However, use of this fertilizer is generally inefficient, as only about a third of the fertilizer applied is actually absorbed by crops, and 50 to 70 percent is

lost from the plant-soil system," writes Shrawat and Good in a recent review on nitrogen [2].

Improving that rate to, say, 70 percent, would have the cost of fertilizer application and prevent a whole bunch of nitrogen run-off, which causes microbial blooms when the nitrogen concentrates in rivers and can lead to oxygen depletion and fish kills.

1. Cheap Hydrogen

Ask just about anyone, particularly in the field of making biofuels from syngas, what they would like to see a lot more of and they will tell you "cheap hydrogen." To make a hydrocarbon fuel from syngas, you not only need hydrogen, but you also need it in the right ratio with syngas' other product, carbon monoxide, to make your process efficient and affordable.

But there's another reason to look at this as a game changer. Companies like LanzaTech are now coming forward with magic bugs that can ferment CO2 into fuels. Imagine taking all that coal-fired power flue gas and turning it into a substitute for imported fossil oils. Well, you need cheap hydrogen to make the process work economically; the more fuel, the more hydrogen. It's also needed to turn renewable oils into renewable diesel and jet fuel, using the hydrotreating process as developed by UOP.

Currently, hydrogen is commercially produced from natural gas and releases CO2 as a byproduct — so that's going in the wrong direction. One good source: Seawater. Here's a review [3] of some of the latest work on developing catalysts that can make that process affordable.

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