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The Biofuels Conundrum

THIS STORY BEGINS WITH GOOD NEWS, FOLLOWED BY A PROBLEM. MANY GOVERNMENTS around the world, and even some states within the United States, are finding ways to reduce greenhouse gas emissions. A major step is the almost completed buyout of the giant Texas electric utility TXU by an improbable concatenation of big investors, environmental organizations, and bankers. This promising deal would kill 8 of 11 projected coal-fired power plants and require the others to meet environmental performance standards. That's like a 15th seed making the final four or Watford winning the FA Cup. Meanwhile, there is hopeful talk in Silicon Valley about "clean tech," and "biofuels" is the new entrepreneurial mantra there. But the problem is that limiting carbon emissions with biofuels like ethanol is complex terrain, and most proposals turn out to carry external costs.

Let's start with the explosive growth of a corn ethanol industry in the tallgrass prairies of America's West. This boon for those rural economies succeeds a long history of dual-purpose farm legislation, in which production objectives are mixed with rural welfare goals. Refineries now number well over 100 with more being added rapidly, as farmers expand cultivation into lands formerly set aside for conservation and drop soybeans to make room for corn. Even if corn could yield 30% of the equivalent energy of gasoline (the goal set by the Secretary of Energy), that would create a whole array of collateral distortions. One would be its environmental impact in the United States. Another would be distortion of the price structure of an important grain commodity that is traded in world markets and used in livestock production. Will that make maize or meat more affordable to poor countries that must import it, or to the poor people who need to buy it? Not likely.

Ethanol derived from sugar cane is better: Growing the plant is energetically less costly, and extraction and fermentation are more efficient. That's what must have interested President Bush during his "Chavez shadow tour" of South America in March. Of course, U.S. companies would love to import this valuable product, which now accounts for a quarter of the ground-transportation fuel in Brazil. Despite such hopes, some senators supporting alcohol-from-corn have helped lay a heavy U.S. protective tariff on Brazilian alcohol derived from sugar. If we got rid of that, it would reduce total carbon emissions, though only if Brazil could expand its production substantially. Is there some deal in progress? Alas, nothing's up.

Sugar alcohol is better than corn alcohol, but palm oil is even better in your tank (though not in your martini). Its relatively high energy efficiency per unit volume makes it a good biodiesel fuel. Trucks can run entirely on palm oil, although it is usually mixed with conventional fossil fuels. A large-scale effort is under way to convert lands in Indonesia to palm oil plantation agriculture, with plans to double current production in a few years. But again, the effort has a downside. Not only will the needed rainforest destruction (by burning) partly cancel any energy advantage supplied by the palm oil, but the conversion will also threaten orangutans and other endangered species.

The best course is to abandon this cluttered arena and invest seriously in a direct approach. As Chris Somerville pointed out in this space,* the conversion of cellulosic biomass (corn stover, wood chips) has a far higher potential for fuel production than any of the above biofuels. The challenge is biochemical: Plant lignins occlude the cellulose cell walls; they must be removed, and then the enzymology of cellulose conversion needs to be worked out. The technology is complex.† No commercial reactor has yet been built, though six are funded. Some hope has been raised by new commitments, like the $500 million joint project between British Petroleum and the Universities of California and Illinois. Nevertheless, as Somerville notes, the sobering reality is that what the U.S. government spends on all of plant physiology is only one-hundredth of the research budget of the National Institutes of Health. That's far too little for a venture this important.

-Donald Kennedy

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*C. Somerville, *Science* **312**, 1277 (2006). †R. F. Service, *Science* **315**, 1488 (2007).

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