Lee Lynd

Reflecting on progress in the bioenergy sector, Lee Lynd considers the prospects of producing liquid biofuels on a scale sufficient to impact energy challenges.

In January the Obama administration pledged to increase funding for research to provide clean energy, building on the initiative started by President Bush in 2006. Lee Rybeck Lynd is the Paul and Joan Queneau Distinguished Professor of Environmental Engineering Design and adjunct professor of biology at Dartmouth College, cofounder and chief scientific officer of Mascoma (Lebanon, NH, USA), initiator and coordinator of the Global Sustainable Bioenergy Project, and focus area lead for biomass deconstruction and conversion at the US Department of Bioenergy Science Center in Oak Ridge, Tennessee. Here he shares his thoughts on the potential and future of liquid biofuels.

Is it clear the world needs biofuels?

Lee Lynd: Biomass is by far the most viable sustainable source of liquid fuels today, and liquid fuels are by far the simplest energy-storage medium for transportation. Liquid fuels provide greater than 50% of US transportation energy in aggressive scenarios for electrification of light-duty vehicles, and batteries are impractical for aviation and probably also for long-haul trucks. Fuel distribution and storage are expected to more than double the cost of hydrogen production but are much cheaper for liquid fuels. Biofuels will likely be a significant part of the energy supply picture for the indefinite future if key obstacles can be overcome.

Can costs of cellulosic fuels be competitive with fossil fuels?

LL: Cost is a surmountable barrier. Refined products from petroleum costing $75 per barrel (about $13.5 per gigajoule) are worth about $100 per barrel. At $60 per dry ton, which is $4 per gigajoule, the price of cellulosic biomass is about a third the price of oil. Thus, the cost of biomass refining can be three times that of petroleum refining and still produce products at a competitive price. Cellulosic biomass is not inherently more difficult to process than petroleum. Petroleum has the advantage of being a fluid, but biomass is more reactive and much more amenable to biotech. The scale of production has less impact on the relative cost of processing cellulosic biomass and petroleum than is often assumed.

What about feedstock supply issues?

LL: The land needed to provide for mobility using biofuels is influenced by the site range and productivity of biomass crops, the extent of integration with other agricultural activities, the conversion process yield, fuel demand, food production and diet. I see increasing evidence that some combinations of these variables allow graceful production of biofuels in very large amounts. In the Blue Map scenario of the International Energy Agency, based on reducing greenhouse gas emissions to 50% of current levels by 2050, biomass provides 23% of primary energy. I think it is probably possible to produce enough biofuels to meet the world's transportation needs, perhaps several times over, while feeding humanity, not clearing wild land, and maintaining or enhancing environmental quality. Systematic analysis of this possibility, the focus of the Global Sustainable Bioenergy Project, is however in the relatively early stages.

How important will biotech be?

LL: Likely important and likely twice: once in feedstock production and again in biological conversion of feedstocks to fuels. I expect that biotech will play a central role in production of cellulosic biofuels. Regardless of processing technology, biotech is a powerful route to develop desired traits in feedstocks.

Which microbes will be most important for cellulosic biofuels?

LL: Development of microbes able to produce cellulosic biofuels without added enzymes—the holy grail for low-cost processing—can be pursued by two approaches. Start with established industrial microbes, which generally do not ferment cellulose, or start with cellulose-fermenting microbes from nature, which are not industrial microbes. My guess is that this development will occur first commercially using established industrial microbes but will ultimately work best with naturally cellulolytic microbes.

What about algae?

LL: Algal biofuels should be investigated as an alternative to petroleum-based fuels. That said, light only penetrates about a centimeter into a thick cell suspension, and surface-to-volume ratios are huge for algal culture as a result. I am doubtful that this challenge can be overcome at the low costs required for bulk fuel production, but this is an important focus for research.

How important will it be to produce a diverse range of biofuels?

LL: Cost-competitive conversion of lignocellulose, the most important next step for biofuels in both societal and commercial contexts, will likely occur over the next few years and will likely involve production of ethanol in order to avoid compounded technical risk. I expect commercial production of infrastructural compatible fuels from readily fermented feedstocks (for example, corn, sugarcane) to also occur during this time. Thereafter, it is likely that fuel molecules in addition to ethanol will be produced from cellulosic biomass to accommodate a diversity of transportation modes. Cost and performance, including environmental performance, will be the key factors in determining the mix of biofuels, and will likely prove more important than compatibility with existing infrastructure. The idea that biofuels have to be compatible with existing infrastructure amounts to saying that a system we know has to change is not capable of changing. We wouldn't get very far applying that approach to electric or hydrogen-powered vehicles.

Why do experts reach such different conclusions about the merit of biofuels?

LL: The optimists' and pessimists' views are widely interpreted as different answers to the same question but are actually answers to two different questions. Whereas optimists ask, "What could be the role for biofuels given innovation and change to achieve a sustainable outcome?", pessimists ask, "What would be the consequences of expanding biofuels based on extrapolating current practices and trends?" The main criticism of the optimists' view is that the changes they argue are possible may not occur. The main criticism of the pessimists' view is that extrapolating current practices and trends does not lead to a desirable energy future. We need to develop a better understanding of the potential of biofuels unconstrained by current practices and trends, and then use that understanding to inform our path going forward.