Biofuels: Today's Realities, Tomorrow's Promise

Perhaps nowhere is the great boom in clean energy and renewables as visible as in biofuels. Ethanol and biodiesel refineries have popped up like mushrooms across the farm belt of the United States and the rapeseed fields of Europe.

Flexible fuel vehicles are flying out of showrooms and into the cities and motorways of Brazil on the power of sugarcane. And in labs across the world, scientists and engineers believe that they are closer than ever to designing cost competitive microbes that can chew up cellulosic material - the tough and inedible parts of a plant - and convert it into liquid transportation fuel.

Most of today's biofuels industry is based on fairly well-understood technology, but there is no doubt that technological innovation will drive the next wave of advancement in the industry.

By the end of 2007, biofuels production worldwide (both ethanol and biodiesel combined) was about 16 billion gallons - the equivalent of over one million barrels per day (mbd) in the unit of measurement used most commonly in the crude oil market.

Production has increased on average by approximately 20 percent per year since 2000. Despite this impressive recent growth, the scale of the biofuels industry should be kept in perspective. Today, the share of biofuels in the global road transportation liquid fuel market is only two percent in energy terms. A huge amount of future growth will be needed even to make a dent in petroleum's monopoly.

What has driven the biofuels boom? Governmental support in the United States, Europe, Brazil and elsewhere has been the single most important reason for the rise in biofuel use over the past several years.

Tax credits, blending mandates and other policy tools are the key levers. The Energy Security and Independence Act of 2007, passed in December, is the most dramatic example of such policy support. It mandates 36 billion gallons of renewable fuels in the U.S. market by 2022 (see The New Renewable Fuels Standard: Historical and Required Volumes of U.S. Biofuels, 2008-2022).

This is equivalent to 2.3 million barrels of motor fuel and is volumetrically equivalent to about a quarter of the gasoline used in the United States today.

Political support for biofuels spans the ideological spectrum. Boosting rural income has always been a key aim of biofuel policy around the world. But now biofuels are being bolstered for energy security and environmental considerations.

Biofuels are projected as the best supply side option for reducing road transportation fossil fuel usage, since they are the only alternative fuels available on a relatively large scale in today's marketplace.

But the boom in biofuels has not been free of backlash and controversy, which has been building recently. As the industry has scaled up, the "food versus fuel" debate has become more vocal - with price, environmental and ethical issues all becoming part of the argument.

Criticism of the biofuels industry has intensified in recent months, especially in light of rising food prices worldwide. Wheat, corn and soybean prices are all currently at or near their all-time highs.

Poor harvests from various key producers around the world, and the rising caloric needs of the growing and increasingly middle-income populations of China, India and the rest of the developing world are two factors behind this inflation in food prices. But the sharp increase in demand for grain and vegetable oil from the biofuels sector has unquestionably been a contributing factor as well.

The environmental sustainability of certain aspects of the biofuel sector is also increasingly under fire. Perhaps the biggest emerging question is biofuels' overall impact on greenhouse gas (GHG) emissions relative to conventional petroleum-based fuels.

Increasingly sophisticated life cycle analyses - which examine all the fossil fuel inputs required to fertilize, harvest, convert a crop into biofuel and then ship it to market - are being used to assess this impact.

The newest studies quantify the important effects of land use changes - estimating the GHG emissions released as land is cleared to plant biofuel crops and make room for additional crops needed to maintain food production.

Ethanol derived from corn starch - over 40 percent of world biofuel production - continues to be the center of this debate. Many studies have analyzed

whether corn-based ethanol reduces GHG emissions, when compared against gasoline.

These studies suggest that even without considering land use changes, GHG emissions over the life cycle of corn-based ethanol are very close to those of gasoline, owing to the many fossil fuel inputs throughout the corn growing and ethanol conversion process. On the other side of the world, natural "carbon sinks" such as the Southeast Asian tropical forest are being cleared to accommodate palm plantations that grow feedstocks for biodiesel.

Environmental nongovernmental organizations (NGOs) have pointed out that the reduced GHG absorption capacity from the loss of tropical forest offsets any GHG savings from using palm-based biodiesel. In response to findings of this sort, the European Union has proposed a draft law that would prohibit the import of biofuel feedstock like palm oil grown on environmentally sensitive land.

There is less controversy about corn-based ethanol's biggest rival - sugarcane-based ethanol, which is produced mostly in Brazil and uses very few fossil fuel inputs during its production life cycle. Next generation biofuels converted from cellulosic plant material are also expected to have a favorable GHG emissions profile, although their impact on global land use will need to be assessed.

With all this uncertainty, what is the future for biofuels? Our study of this nascent industry suggests that, above and beyond the environmental questions already raised, it faces several key challenges going forward.

The biofuels resource base is limited by the amount of land that must remain under cultivation for food, animal feed and fiber production. Therefore a biofuel's "footprint" matters. In the future, the most successful biofuels feedstocks will be crops that do not compete with food and which maximize the volume of liquid fuel that can be converted from a unit of land.

Economics is another major challenge for bio-fuels. Biofuel production costs are highly dependent on the price of the underlying agricultural commodity. But a biofuel's market price may depend on other factors as well, such as the prevailing world petroleum price. This can put a squeeze on the industry at times - for example, if oil prices weaken just as corn prices rise.

Moreover, as the price of petroleum increases, increased production from the biofuel industry tends to put even more upward pressure on crop prices, pushing production costs higher. Cellulosic feedstocks will be cheaper, but the capital costs to build next generation bio-refineries are formidable.

A third challenge is quality. While biofuels are substitutes for traditional petroleum fuels, they do not necessarily deliver the same performance. For example, ethanol has a lower energy content relative to gasoline, which results in a loss of fuel economy. Biodiesel tends to perform poorly in cold weather.

For mass consumer acceptance of biofuels, they will ultimately need to deliver reliability and functionality that is equal to or superior to that provided by petroleum-based fuels. A key aim of next generation biofuels technology is to design biomass-based molecules that deliver this performance.

Finally, the role of advanced technology will be critical for biofuels. The industry needs better molecules, better feedstocks and better conversion technologies. Game-changing advances such as the conversion of biofuels from cellulosic plant material will be necessary to expand the resource base beyond food-based crops.

Advanced technology will also play a key role in improving the sustainability and GHG emissions reduction potential of the biofuels industry. The only way in which biofuels can make a truly sizable dent in petroleum's monopoly on the transportation fuels market is if next generation biofuels technology becomes commercially viable at scale.

It is important to remember that the biofuel industry is not monolithic. From conventional ethanol derived from corn starch to synthetic fuels derived from cellulosic plant material, biofuels differ widely in terms of their production pathways and carbon footprint, feedstock availability, competition with food, as well as production cost structure.

These differences will determine the limits to scalability for each technology. But it is clear that biofuels will be a growing part - both figuratively and literally - of transportation fuels around the world.

About the Author

Daniel Yergin, chairman of CERA, received the Pulitzer Prize for "The Prize: The Epic Quest for Oil, Money & Power" and the United States Energy

Award for lifelong achievements in energy and the promotion of international understanding. Vist CERA.