Are Ethanol and Other Biofuel Technologies Part of the Answer for Energy Independence?

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There are many energy resources and technologies that can be developed to replace a nation's dependency on petroleum imports. However, the energy alternatives become more limited if the three following objectives are to be met:

- Reduced susceptibility to supply-line interruptions and the negative economic results from international terrorism, the whims of oil cartel pricing, and natural disasters such as earthquakes and hurricanes.
- Stimulation of rural economies, as well as the nation at large, by increasing agricultural and business opportunities while reducing the export of currencies to pay for energy.
- Protection of the environment through the reduction of emissions and reduced depletion of habitat and natural resources.

Many believe that renewable energy resources should provide the United States with some of the best opportunities to develop domestic energy resources not subject to terrorism, economic extortion, or natural disasters such as hurricanes and earthquakes.

The proponents of renewable energy believe that the development of such resources provides much needed stimuli to the economy of rural America through the establishment of additional markets for cash crops, such as corn and soybeans, and the development of facilities to produce energy products such as ethanol.

Last, renewable energy can be cleaner than other energy sources and have less negative impact on the environment.

However, there are some additional issues to consider when finding an energy substitute to replace petroleum, even if the energy source is a renewable one. Important questions include:

- Can the energy be produced at large enough quantities to really affect dependency on imported petroleum?
- Can the production and processing of alternate fuels create economic opportunity with little displacement to local communities or minimum environmental impact?
- Can renewable energy sources be integrated into current production, processing, infrastructure, logistics, and delivery systems?
- Can manufacturers of vehicles transition from existing technology to new technology with relative ease?
- Can this energy work in tandem with other energy technologies such as hybrid vehicles?

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The first question posed may arguably be the most important question.

The answer may be "yes" if biofuels such as ethanol are considered as candidates. Many scientists, businessmen, and government officials believe that ethanol from corn holds great promise.

Ethanol (ethyl alcohol, grain alcohol, EtOH) is a clear, colorless liquid. It (CH_3CH_2OH) is made up of a group of chemical compounds whose molecules contain a hydroxyl group, -OH, bonded to a carbon atom. Ethanol made from cellulosic biomass materials instead of traditional feedstocks (starch crops) is called bioethanol. Ethanol performs as a fuel and fuel oxygenant: ethanol improves the octane value and reduces the pollutant emission levels of gasoline fuels.

According to the U.S. Department of Energy, the United States produced four billion gallons of ethanol from corn during 2005, providing enough ethanol to meet 2% of this nation's gasoline consumption. It is currently estimated that production for the current year (2006) will be somewhere around five billion gallons or enough to supply 3% of the nation's gasoline consumption.

Critics will be quick to point out that replacing 2 or 3% of the nation's gasoline consumption is a drop in the bucket and there is no way the United States can produce enough biofuels, such as ethanol, in the upcoming years to make a difference. These critics are right if they see things the way they were and base their pessimism on little or no change in biomass acreage and sources, no improvement yields, and no new biofuel processes.

However, consider this, according to the Renewable Fuels Association, there are already 106 ethanol biorefineries in production in the United States as of October 2006, another 46 under construction, and 7 expansions. The vast majority of these biorefineries use corn as the feedstock. Others are operating using a combination of corn and wheat, or barley, sorghum, or milo as feedstock. Yet other biorefineries use cheese whey or brewery wastes.

Vinod Khosla (former partner in Kleimer Perkins, cofounder of Sun Microsystems, and founder of Khosla Ventures) predicted recently at the Advancing Renewable Energy: An America Rural Renaissance Conference that corn ethanol production will peak at 14.6 billion gallons during 2014 and should remain at that level over the next few decades (1).

Khosla further predicted that during the same time period, ethanol production will become robust enough to provide 13% of the U.S. gasoline demand (Table I).

It is expected that corn ethanol will provide the majority of the feedstock for ethanol production through 2014 and at the end of 2015, cellulosic ethanol will provide an increasing percentage of ethanol. By some estimates, by the year 2029, the combined production of corn ethanol and cellulosic ethanol could provide as much as 74.5% of the nation's demand for gasoline with 91.2% of production being provided by cellulosic ethanol

Even if the combined production of corn and cellulosic ethanol is half of what it is projected to be in 2020, its contribution of more than 37% to meet gasoline demand is still significant. Certainly it is a large enough quantity of fuel to be strongly considered as a replacement for gasoline made from petroleum.

The production of energy has created some of the greatest benefits as well as some of the most negative impacts on many local communities and the environment. So, it may be prudent to ask if the production and processing of ethanol and other biofuels can create economic opportunity with little negative impact to local communities and the environment.

The U.S. Department of Agriculture and U.S. Department of Energy believe that renewable energy, including ethanol, will create a renaissance in rural America. In fact, the departments feel so strongly about the positive impact of renewable energy that they co-hosted the conference at which Vinod Khosla spoke. Speakers at the conference included the secretaries of Energy and Agriculture, four undersecretaries, the USDA head economist, the EPA head, more than two dozen CEO's and association heads, and a former director of the CIA.

Many of the speakers commented on how renewable energy can and is sparking a renaissance in rural America. The locations of the 106 ethanol-production facilities listed by the Renewable Fuel Association are without exception in rural communities. As one would expect, the overwhelming majority of the ethanol facilities are in the midwestern agricultural states. However, there are also ethanol production facilities located far from the heartland on both coasts of the United States.

Most of the communities where production facilities are located are small towns, for which the addition of a corn ethanol facility that employs between 10 and 35 people can have a significant economic impact. In addition, ethanol provides farmers, the economic linchpins of rural communities, a new, guaranteed market for their crops.

As cellulosic ethanol production develops, it too will prove a boon for rural America. Cellulosic production will occur in many parts of the country, including those where the forestry industries are important. Again, small ethanol plants will be built to capture cellulosic biomass. These plants may utilize the waste currently left on the forest floor when trees are harvested, delimbed, and topped prior to loading on trucks. In other sectors of the United States, biodiverse feedstocks for cellulosic ethanol may include switchgrass and eucalyptus trees.

Biodiesel is another biofuel that is already appearing at some retail locations. One of the primary feedstocks for biodiesel

Table I. Prediction of future ethanol production[a]

Year	Corn Ethanol[b]	Cellulosic Ethanol[b]	Total Corn and Cellulosic Ethanol[b]	Ethanol from Corn (%)	Ethanol from Cellulosic (%)	Ethanol Product for Gasoline[b]	Demand for Gasoline (billion gallons)	Gasoline Demand Being Filled by Ethanol (%)
2005	4	0	4	100.0	0.0	3.2	140	2.3
2006	4.8	0	4.8	100.0	0.0	3.8	141.4	2.7
2007	5.8	0	5.8	100.0	0.0	4.6	142.8	3.2
2008	6.9	0	6.9	100.0	0.0	5.5	144.2	3.8
2009	8.3	0.1	8.4	98.8	1.2	6.7	145.7	4.6
2010	10	0.8	10.8	92.6	7.4	8.6	147.1	5.8
2011	10.9	2.5	13.4	81.3	18.7	10.7	148.8	7.2
2012	12	4.4	16.4	73.2	26.8	13.2	150.1	8.8
2013	13.2	7.2	20.4	64.7	35.3	16.4	151.6	10.8
2014	14.6	10.4	25	58.4	41.6	19.9	153.1	13.0
2015	14.6	14.6	29.2	50.0	50.0	23.3	154.6	15.1
2016	14.6	19.4	34	42.9	57.1	27.1	156.2	17.3
2017	14.6	24.8	39.4	37.1	62.9	31.5	157.8	20.0
2018	14.6	31.1	45.7	31.9	68.1	36.5	159.3	22.9
2019	14.6	38.2	52.8	27.7	72.3	42.2	160.9	26.2
2020	14.6	46.2	60.8	24.0	76.0	48.6	162.5	29.9
2021	14.6	54.8	69.4	21.0	79.0	55.5	164.2	33.8
2022	14.6	64.3	78.9	18.5	81.5	63.1	165.8	38.1
2023	14.6	74.4	89	16.4	83.6	71.2	165.7	43.0
2024	14.6	85.3	99.9	14.6	85.4	79.9	169.1	47.3
2025	14.6	97.2	111.8	13.1	86.9	89.4	170.8	52.3
2026	14.6	110.2	124.8	11.7	88.3	99.6	172.5	57.7
2027	14.6	124.4	139	10.5	89.5	111.2	174.3	63.8
2028	14.6	140	154.6	9.4	90.6	123.6	176	70.2
2029	14.6	150.9	165.5	8.8	91.2	132.4	177.8	74.5

[a] Data from Appendix A from Is Ethanol Controversial? A White Paper by Vinod Khosla, September 2006.
[b] Production in billion gallons.

is soybeans. The end product is a vegetable oil. Already, some companies are actively marketing biodiesel. The product is a blend of 80% biodiesel fuel with 20% petroleum-derived diesel. The benefits to rural farm communities are similar for biodiesel as they are for corn ethanol production.

The United States can meet many of its energy goals by beginning with corn ethanol, and over time, shifting to cellulosic ethanol and other biofuels. From a practical point of view, it would appear that even the worst ethanol or biodiesel plant in operation today provides less damage to local communities and the environment than that caused by most, if not all, oil refineries.

What about processing and delivery? Can renewable energy biofuels be easily integrated into current production, processing, logistical, infrastructure, and delivery systems?

The answer is yes. As an oxygenant, ethanol is more corrosive than gasoline and requires precautions to be taken to prevent its corrosiveness from damaging storage tanks and dispensing pumps.

Admiral Woolsey, former CIA head under the Clinton administration, believes that the very nature of ethanol production in small plants scattered across a wide geographic area is beneficial since scattered energy assets are more difficult to disrupt through terrorist attacks or natural calamities such as hurricanes or earthquakes.

Underwriter's Laboratories, Inc. (Northbrook, IL) is currently working to certify E-85 pumps (a mixture of 85% ethanol and 15% gasoline). There are nearly 1,000 locations in the United States that already pump ethanol to consumers.

Biodiesel is ideal as an alternative, renewable fuel. It can be stored in standard storage tanks and handled just like diesel produced from petroleum. Biodiesel can be admixed with diesel fuel in storage tanks or vehicles. In addition, it is biodegradable.

Can vehicle manufacturers change from existing technology to new technology with relative ease is a question that is of paramount importance.

The answer is yes for biodiesel and ethanol. While it is suggested that owners of diesel vehicles check with the vehicles' manufacturer before using biodiesel fuels, there are no major modifications that need to be made to diesel engines to operate on biodiesel.

General Motors, Ford, and other U.S. automotive manufacturers are already introducing models of cars and trucks that can operate on either E-85 or regular gasoline blends. These are the so-called "flex fuel" vehicles, a concept that is already successful in some countries such as Brazil. In addition, automobile owners can have their existing vehicles altered to operate on E-85. However, as with biodiesel, it is not recommended that vehicle owners use E-85 unless they ascertain in advance that their vehicles were designed for flex fuel or consult with their vehicle manufacturer on how to make the necessary modifications to the vehicle's engine to accommodate flex fuels.

Can bioenergy work in tandem with other energy technologies such as hybrid vehicles?

The lithium battery industry is on the edge of a technological breakthrough that will allow future owners of hybrid cars to travel between 20 and 40 miles (32–64 km) before having to rely on the internal combustion element of their hybrid vehicle's power system. The fact that commuters may be able to travel as much as 40 miles (64 km) without relying on gasoline should certainly lower the gasoline consumption of hybrids. Now, imagine the economic implications if such a hybrid vehicle of the future combines a flex-fuel internal combustion engine with an E-85 ethanol fuel mixture? Given that new vehicles in the United States average approximately 20 miles per gallon (8 km per liter) of gasoline, what degree of energy savings are possible?

The owner of such a hybrid vehicle could drive their hybrid car for 100 miles (160 km) and use no gasoline or ethanol for the first 40 miles (64 km) Given that the hybrid's internal combustion engine achieves 30 miles per gallon (12 km per liter), it will consume only two gallons (8 liters) or less of gasoline for the remaining 60 miles (96 km) of the trip. However, with an E-85 fuel mixture, the hypothetical hybrid vehicle will consume only 0.3 gallons (1.2 liters) of gasoline and 2.7 gallons (11 liters) of ethanol for the entire 100-mile (160 km) voyage. This represents a net reduction from 5 gallons (20 liters) of petroleum-based fuel to only 0.3 gallons (1.2 liters of petroleum-based fuel). In 1999, according to the U.S. Department of Transportation, transportation needs accounted for 67% of the United States' total petroleum demand. (1).

Given today's political, economic, and environmental climate, (biofuels tend to be cleaner), it is likely that countries like the United States will experience significant increases in grain demand from the biofuels industry over the foreseeable future. Some of this increased demand may be satisfied by additional farm acreage. However, it is likely that competition for all available grain stocks will become more acute in the future until alternate cellulosic ethanol-production technologies come online.

In summary, the growing confluence of grain-derived biofuels and cellulosic ethanol-production technologies with the development of new transportation technologies will have significant political, economic, and agricultural implications, domestically and globally. However, one must weigh the consequences of not developing ethanol as a renewable energy resource against the serious consequences of severe energy shortages that could cripple entire sectors of the world's economy. Industries that ignore these economic trends do so at their peril.

Reference

1. U.S. Department of Transportation Press Release. Online publication at http://www.dot.gov/affairs/bts1201.htm, June 5, 2001.

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