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State of the Union: Replacing Gasoline with Biofuels

When the President of the United States discusses switch grass in the state of the union, you know something has changed. *"We'll also fund additional research in cutting-edge methods of producing ethanol, not just from corn, but from wood chips and stalks, or switch grass. Our goal is to make this new kind of ethanol practical and competitive within six years,"* said President Bush[1]. The speech recognized the need to reduce our nation's consumption of oil by substituting alternative fuels or biofuels for gasoline. Switch grass is one example of an environmentally friendly crop that could be harvested and converted into transportation fuel. In this article, we look at what it would take to economically replace gasoline with biofuels.

A fleet of flexible fuel vehicles would allow consumers to chose between gas and biofuels. The competition would save consumers money and move the U.S. towards energy independence. Shown above is the prototype Ford Escape Flexible Fuel Hybrid. (Photo courtesy of the Ford Motor Company.)

The Current Situation

The U.S. consumes about 150 billion gallons of gasoline per year. Currently, we consume nearly 21 million barrels[2] of petroleum per day. Gasoline is the largest single product made from that petroleum. Our dependence on foreign sources of oil funnels billions of dollars to shaky and hostile regions, increasingly causing defense and foreign policy experts to cite our oil addiction as a "national security emergency." Our reliance on foreign sources also undermines our economic stability, exposing our markets to price shocks; spikes in oil prices have preceded each of the major recessions over the last 30 years.

America's cars, trucks and buses account for 27 percent of U.S. global warming pollution. Thus, a "climate friendly" domestic fuel is desirable for economic, security and environmental reasons.

Over the last few years, federal mandates for gasoline additives have increased the use of ethanol, which now accounts for about 3 percent of our gasoline supply. Ethanol, derived primarily from corn, is blended in quantities of up to 10 percent in gasoline (also called E10 or low-blend); the maximum amount that all vehicles sold in the U.S. are certified to handle. Existing federal policy enacted in last year's energy bill called "EPAct 2005,"[3] will increase the volume of ethanol from the current 4 billion gallons/year to 7.5 billion. Low-blend alone will not solve our problem because existing vehicles are not designed to exceed E10 and recent evidence has shown that there are air

[1] State of the Union 2006 website: <http://www.whitehouse.gov/stateoftheunion/2006/index.html>.
[2] Energy Information Administration. Annual Energy Outlook 2006. Report #:DOE/EIA-0383(2006). Feb 2006. Available online at <http://www.eia.doe.gov/oiaf/aeo/index.html>.
[3] See U.S. Department of Energy webpage: <http://www.energy.gov/taxbreaks.htm>.

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quality risks with using low-blend ethanol in warm weather in air basins with already poor air quality. In order to achieve independence from foreign sources of oil, while minimizing environmental impacts, we must pursue the growth of a high-blend ethanol market and vehicles that are certified to use it. It also requires expanding beyond corn-based ethanol to cellulosic ethanol.

Thus, the President's goal requires vehicles that run primarily on biofuels - not gasoline.

We Only Need Three Things!

The U.S. needs three things to have a fuel that is competitive with gasoline:

1. Cars that can run on either gasoline or alternative fuels
2. Alternative fuels that compete with the expected price of gasoline
3. An infrastructure to deliver the fuel conveniently to consumers

All three exist today but in too limited a choice of vehicles, too low a volume, and in too few stations. In a six-year timeframe, the only likely alternative fuel candidate is E85 (85 percent ethanol and 15 percent gasoline). E85 can be delivered through existing gasoline retail infrastructure and run in flexible fuel vehicles (FFV), which can operate on any combination of gasoline and ethanol.

Flexible Fuel Vehicles

All U.S. vehicles can run on a mixture of gasoline and up to 10 percent ethanol. To use more than 10 percent, the vehicle must be specifically designed to be a "flexible fuel vehicle" (FFV). An FFV has a fuel system which can handle the more corrosive properties of ethanol, a sensor to measure the percentage combination of ethanol and gasoline, an adjustment mechanism enabling engine calibrations and special injectors. Ford Motor Company estimates the incremental cost of a FFV vehicle at $100 to $150 per unit. In addition, an FFV must be re-certified to verify it meets federal and state emissions standards - adding a significant one-time cost.

FFVs provide considerable consumer choice by allowing customers to shop for cheaper fuel - using E85 when oil prices are high and gasoline when oil prices are low. This consumer-choice model has worked extremely well in Brazil, where ethanol now comprises 40 percent of the market and FFVs are widespread.

In the U.S. there are about 5 million FFVs, not due to consumer demand, but because a manufacturer gets a "credit" on their fuel economy requirements for every FFV they produce. This is true even if the car never runs on anything except gasoline. This federal law from 1988 has allowed manufacturers to continue to produce vehicles with lower fuel economy with no public benefit.

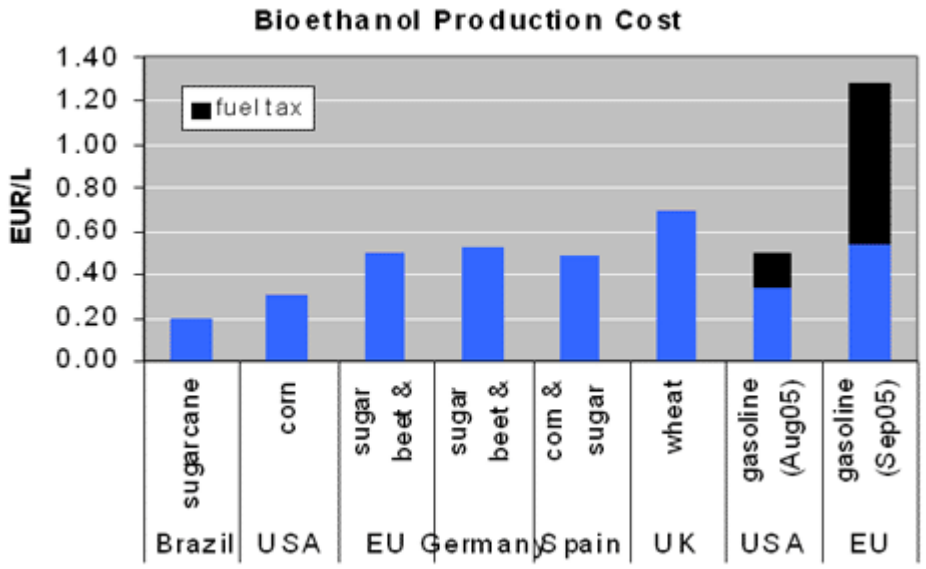
In 2006, U.S. manufacturers are expected to sell between 700,000 and 1,000,000 FFV vehicles and both GM and Ford are mounting significant consumer campaigns to get FFV owners to use E85. The increase in FFV's necessitates an increase in E85 fueling stations and auto companies want to see more E85 pumps available. Ford is focusing in the Midwest in partnership[4] with VeraSun, a major ethanol producer. General Motors announced a relationship[5] with Shell Oil Products and VeraSun to add 26 E85 pumps in the greater Chicago area.

[4] VeraSun Energy. "Ford and VeraSun Announce Partnership to Drive Ethanol Infrastructure." Press release. 4 Nov 2005. Available online at <http://www.verasun.com/releases_11_4_05.htm>.
[5] General Motors. "GM Promotes Greater E85 Consumer Awareness, Use." Press release. 8 Feb 2006. Available online at <http://media.gm.com/news/releases/viewmonthlyarchive.jsp?month=2&year=2006>.

To achieve wide-spread production and use of E85 we will need the majority of new U.S. vehicles to be available as FFVs. There are two general paths for making this happen. The federal government (or possibly states) could mandate a phase-in of FFVs (in fact, the "Vehicle and Fuel Choices for American Security Act" - S. 2025 and H.R. 4409 - does just that). Alternatively, if U.S. consumers made FFV capability a purchasing criteria, the car companies would happily increase FFV production to respond to demand. However, consumer demand is contingent upon E85 being widely available and being less expensive per mile driven than gasoline.

Competing on Price

As the chart below shows, there were a variety of crops in various countries that produced ethanol at production costs competitive with gasoline during 2005. (Note that these are production costs in Euros per liter, and not the actual sales price.)



Source: The Economist, New Energy Finance, DOE, UK Petroleum Industry Association (via: Imprimatur Capital)

The production price of gasoline in California is approximately $.61 per gallon for refinery costs plus the price of crude oil (see Weekly Transportation Fuels[6]). At a cost of $42/barrel, the production cost of gasoline is $1.61 per gallon (there are 42 gallons per barrel). In the U.S., ethanol made from corn has a production cost less than $1 per gallon (exclusive of equipment depreciation) and during the period of $40-a-barrel oil, it was being sold to refineries for about $1.20/gallon.

There is less "energy density" in ethanol and thus a car optimized for gasoline will get less miles per gallon with ethanol. There are no complete studies on what the actual mileage is (see Gasoline vs. E85[7] for an example). The theoretical worst case is about 1/3 fewer miles per gallon. Most drivers report a 5 to 20 percent reduction in miles per gallon. Using the 1/3-worst-case, one would have to discount the value of ethanol by 1/3, making it about $1.60 per gallon-equivalent of gasoline. Thus, without any tax benefits (the federal government offers a $0.51/gallon excise tax credit per gallon of

[6] Accessible online at <http://www.energy.ca.gov/gasoline/index.html>.
[7] Dawson, Barbara. "8 On Your Side Gas Test: Gasoline vs. E85." Television news feature. WQAD/WorldNow. 2006. Available online at <http://www.wqad.com/Global/story.asp?S=3972760>.

ethanol, current corn-based ethanol is price competitive with gasoline at about $42/barrel and above. (Note: The final consumer price of gasoline includes $0.50/gallon in taxes.)

The U.S. Energy Information Administration estimates future costs and consumption of energy from all major sources. Their 2006 annual energy forecast[8] predicts 2010 imported crude oil to be priced at $43.99/barrel and imported low-sulfur light crude at $47.29/barrel. The price during the week of February 19th, 2006 was about $56[9]. World-wide demand will increase during the next six years and volatility of supply is likely to continue. As a result, the government forecast would seem optimistically low. On the other hand, a successful alternative to petroleum could cause OPEC countries to artificially drop prices in order to economically damage the alternative fuels.

Moving to Cellulosic Ethanol

Currently, ethanol is made the same way beer or wine has been produced. A sugar or starch is fermented into alcohol. The two main crops today are sugar cane and corn. Those crops will have incremental improvements in the production process, but they will always be fundamentally limited by availability of land and the cost of production. Most experts expect to make ethanol from the cellulose in plant material and find crops that can produce large amounts of cellulose per acre.

This is where switch grass and cellulosic ethanol comes in.

While there are no major cellulosic production facilities today, private industry and governments are very active in addressing the three factors affecting its use - the amount of biomass per acre, the amount of ethanol that is produced per ton of biomass and the cost of production. There are numerous possible variations on these three factors. We will use switch grass as one illustration.

Today, sustainable methods can be used to produce about 5 dry tons of switch grass per acre per year. Assuming the yield improvements we have seen in other crops (such as corn) can be expected for switch grass, we can speculate on tripling production over time, to 15 dry tons/acre. Current conversions techniques produce about 33 gasoline-gallon-equivalents/ton. According to an NRDC report entitled "Growing Energy,"[10] the conversion should improve to 80 gallons per dry ton over the next 10 to 15 years.

Let's assume for the moment that all 44 million current farm acres in South Dakota were used for biomass. Forty-four million acres multiplied by 15 dry tons/acre multiplied by 80 gallons per ton would yield 53 billion gallons/year, or about one third of the U.S. supply. Converting this to barrels of oil per day, South Dakota would rank 3rd in OPEC country production quotas[11], with 3.4 million barrels/day, behind Saudi Arabia with 9.1 million and Iran with 4.1 million.

Of course, we are not implying South Dakota would do this (although the math shows their farmers

[8] Energy Information Administration. Annual Energy Outlook 2006. Report #:DOE/EIA-0383(2006). Feb 2006. Available online at <http://www.eia.doe.gov/oiaf/aeo/index.html>.
[9] Energy Information Administration. Weekly Petroleum Status Report. 3 Mar 2006. pp. 26. Available online at <http://www.eia.doe.gov/pub/oil_gas/petroleum/data_publications/weekly_petroleum_status_report/current/pdf/table13.pdf>.
[10] Greene, Nathanael, et. al. Growing Energy: How Biofuels Can Help End America's Oil Dependence. Natural Resources Defense Council, Nov 2004. Available online at <http://www.nrdc.org/air/energy/biofuels/biofuels.pdf>.
[11] Energy Information Administration. Short-Term Energy Outlook – March 2006. Table 3a. Available online at <http://www.eia.doe.gov/emeu/steo/pub/3atab.html>.

would get more profit per acre if they did), but rather to illustrate a point. A recent report[12] from the U.S. Department of Energy stated: *"In the context of the time required to scale up to a large-scale bio-refinery industry, an annual biomass supply of more than 1.3 billion dry tons can be accomplished with relatively modest changes in land use and agricultural and forestry practices."* At 80 gallons/dry-ton, this would amount to more than 100 billion gallons.

Estimates done by NRDC (see "Growing Energy") project the cost of such advanced cellulosic ethanol at $.59-$.91/gallon gasoline equivalent. Thus, existing ethanol techniques can compete with oil above $40 per barrel allowing time for cellulosic ethanol to eventually compete with oil at virtually any price anticipated over the next twenty years.

E85 Infrastructure

There are only minor differences between an E85 pump and a gasoline pump. If service stations were so inclined, they could convert gasoline pumps to E85 pumps or add an E85 pump. The most cost-effective way would be for stations with three storage tanks offering low-, mid- and high-octane gasoline to replace the mid-octane tank with E85. (A mid-octane could still be produced by blending the low- and high-octane gasolines.) Such a conversion is possible for under $5,000 if state-certified equipment is already available.

If a new storage tank needs to be added, the costs can easily increase to $25,000 to $50,000 per pump. E85 can be delivered to the station in standard tank trucks.

What would motivate a station operator to offer E85? In Minnesota, a state program provides financial incentives and, as a result, there are more than 100 stations. New York has significant grant funds available in its proposed State budget for making stations E85 capable. In the U.S. overall, the 600 total E85 fueling stations are concentrated in the Midwest, where most of the ethanol is produced. It constitutes a small fraction of the 170,000 total retail gas stations in the U.S. Under the EPAct2005 fueling stations are eligible to claim a 30% tax credit for the cost of installing E85 ethanol pumping stations. This should significantly increase the availability of E85.

The key to increasing the number of pumps may lie in the independent station operators. Their margins are better with ethanol than with gasoline because they can get long term commodity contracts and they can compete on price with the majors since there is a more level playing field for purchasing ethanol than exists in gasoline.

The remaining question is whether the price advantage will be passed on to the consumer. Current E85 pumps generally price their product at a discount to gasoline, typically $0.50/gallon below regular gasoline, or just enough to attract customers. (A consumer needs to compare the actual cost per mile driven with gasoline and E85 for their own vehicle.) As the volume of ethanol increases, we can reasonably expect market forces to drive down the cost to consumers, providing downward pressure on fuel prices that does not exist in today's market.

Low Carbon Fuel

Gasoline made from petroleum takes carbon stored in the ground and releases it into the atmosphere. Ethanol made from biomass takes carbon from the atmosphere, absorbs it into the

[12] U.S. Department of Energy/U.S. Department of Agriculture. Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply. April 2005. Available online at <http://www1.eere.energy.gov/biomass/pdfs/final_billionton_vision_report2.pdf>.

plant material and releases it when burned in the vehicle. The new carbon comes from the fossil fuel energy used to grow crops and make the ethanol. NRDC forecasts that advanced cellulosic ethanol will produce less than 15 percent of the global warming pollution that gasoline produces. Thus, once the free market for E85 comes into existence, it would be in the U.S.'s best interest to have a global warming pollution standard for fuels - just like there are standards for other pollutants. This would help prevent market price fluctuations from causing a shift to higher global warming pollution.

Summary

The President's six-year goal of a competitive cellulosic ethanol industry will help to drive an E85 market as long as three factors occur roughly concurrently: an increase of the FFV fleet of cars in the U.S., advances in ethanol production from an increased variety of crops (including cellulosic ethanol), and an expansion of E85 infrastructure. Consumers have the most to gain from such a transition: competitive fuel prices, increased national security coupled with an economic boost due to domestic sources of fuel, and a low-carbon fuel reducing global warming pollution.

While the corn ethanol market has already taken off as a result of existing federal programs, cellulosic ethanol, FFVs and E85 pumps have not. Cellulosic ethanol is starting to receive significant public and private investments. Auto companies would be happy to make the cars if only there were E85 pumps conveniently located for consumers. Independent station owners (and the majors eventually) would be happy to sell E85 if only there were cars creating demand. Solving the remaining stalemate will mostly likely fall on government policies - or a major economic shock coming from the price or availability of gasoline. A government/private partnership is the best alternative to both spurring and sustaining an E85 market.