REPLACING OIL

ALTERNATIVE FUELS AND TECHNOLOGIES

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Most experts look to alternative fuels and technologies as promising complements to petroleum in the near term and likely substitutes in the long term. Currently, 98 percent of the U.S. transport sector runs on petroleum. The reasons for this dominance are simple. Transportation fuels derived from petroleum pack a lot of energy in a small volume and weight. The internal combustion engine (ICE) found in practically every vehicle is compact, powerful, and well suited to transportation applications. And until recently, petroleum has been a bargain, at least in the United States. If alternative energy sources are to compete effectively with petroleum, they must be price competitive, perform well with existing ICE technology, or be packaged with a new motor entirely, probably an electric one.

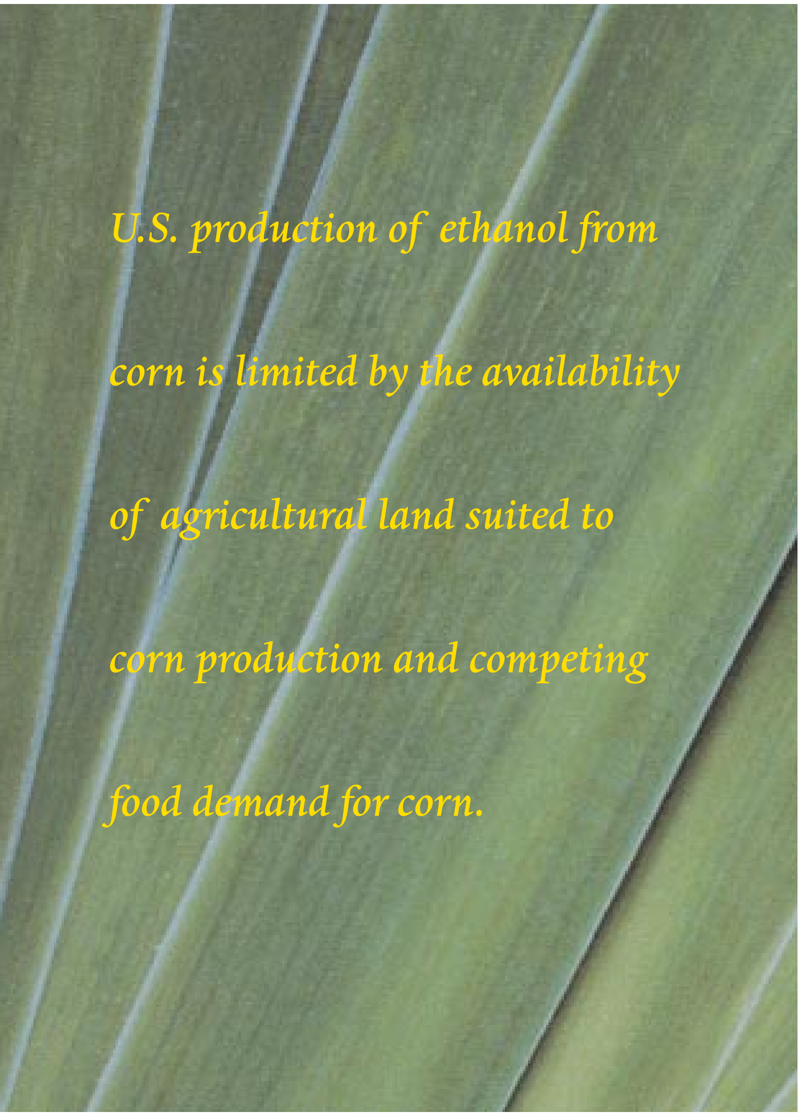
The extent to which alternative fuels can reduce U.S. dependence on petroleum, lessen the impact on U.S. consumers of spikes in the world price of petroleum, and improve U.S. national security through reductions in imported petroleum depends on the scale of their penetration into the transport fuel market. Penetration in turn depends on the cost of delivered alternatives in relation to gasoline and diesel, the degree to which these alternatives are viewed as viable substitutes by consumers, the availability of vehicles designed to utilize the fuels, and the necessary fuel distribution infrastructure.

The advantages enjoyed by petroleum divide the potential competitors into two camps—liquid biofuels (ethanol and biodiesel) that can be used in ICEs and other energy sources, such as hydrogen and electricity, that require new motor technologies. In the case of hydrogen, a radically new delivery infrastructure is also needed. In the near-to-medium term, biofuels are poised to be competitive. In the longer term, hydrogen and electricity offer the technical potential to completely wean the United States from petroleum use.

Biofuels over the Next 5–10 Years

Biofuels seem well positioned to penetrate the transportation market. Ethanol can be produced from corn, sugar, and fibrous plants, such as switchgrass. Currently, 10 percent ethanol is blended with gasoline to make E10, in large part as a substitute for MBTE (once added to gasoline for environmental purposes). However, with limited vehicle modifications costing between $50 and $150 per vehicle, new vehicles can be produced to run on as much as 85 percent ethanol (E85) as well as 100 percent gasoline. These "flex-fuel" vehicles are currently being produced by U.S. automakers; General Motors, for example, estimates that more than two million of its flex-fuel vehicles are on the road in the United States today.

A government subsidy of 51 cents per gallon already makes corn-based ethanol price competitive in the United States with gasoline in the neighborhood of $3.00 per gallon. However, the relatively small quantity of ethanol produced is predominately used in E10 blends. If E85 becomes popular, production must be scaled up, which may raise the cost as demand rises. Further, ethanol has about 70 percent of the energy content of gasoline, which equates to fewer miles per gallon. Therefore, if gasoline sells for $3.00 per gallon, competitive E85 must sell for no more than $2.20 to attract consumers.



The Renewable Fuels Association lists 102 ethanol refineries currently operating in the United States, with an additional 43 refineries and seven expansions under construction. However, U.S. production of ethanol from corn is limited by the availability of agricultural land suited to corn production and competing food demand for corn.

Outside the United States, ethanol has been made for many years from sugar; in Brazil, for example, ethanol from sugar accounts for about 20 percent of the transport fuel market. Indeed, the World Bank believes Brazil can make ethanol from sugar for about $1 per gallon. Unfortunately, imports of ethanol from Brazil face high tariffs, a 2.5 percent tax on the value, and a secondary tariff of 54 cents per gallon, imposed to roughly offset the 51-cents-per-gallon domestic subsidy. Reducing or eliminating these tariffs might expand ethanol supply to the United States, thereby lowering cost and accelerating the penetration of this fuel into the U.S. transportation fuel market

Ethanol can also be produced from woody fibrous plants, such as switchgrass. The use of a low-cost and readily available feedstock has led many to believe that cellulosic ethanol could be very price competitive with gasoline in the future after the production technology has evolved somewhat further. Honda Motor Company recently reported successes using strains of microorganisms developed in Japan to more efficiently convert the sugar in cellulose into alcohol. And unlike corn, biomass for cellulosic conversion need not consume prime agricultural land and, as a result, may be grown in larger quantities.

The Department of Energy forecasts total ethanol production from corn and cellulose to be 10–14 billion gallons annually by 2030. While this would amount to 30 percent of worldwide ethanol production, it is still less than 10 percent of projected U.S. gasoline demand. The president's Advanced Energy Initiative, announced in his 2006 State of the Union speech, will increase research funding for cellulosic ethanol, with the goal of making it cost-competitive with corn-based ethanol by 2012.

Production of biodiesel made from recycled cooking oil (called yellow grease) or raw vegetable oils from crops such as soybeans was developed as early as the invention of the diesel engine in 1878. Like ethanol production, biodiesel enjoys government subsidies that make it price competitive with petroleum. The Energy Information Administration estimated the current cost of a gallon of biodiesel made from vegetable oil to be $2.49 and the cost from yellow grease to be $1.39 in 2002 dollars. In comparison, EIA estimated the cost of diesel from petroleum to be 78 cents a gallon. To compete, biodiesel received a production subsidy from the Commodity Credit Corporation during fiscal years 2004–2006 of $1.45–$1.47 per gallon if made from soybean oil and 89–91 cents per gallon if made from yellow grease.

On top of this production subsidy rests a tax credit for blenders who add biodiesel to petroleum diesel. The blenders receive a credit against the federal excise tax they pay of approximately $1.00 per gallon for vegetable oil-based diesel and 50 cents per gallon for yellow grease. These subsidies and tax credits bring the production cost of biodiesel very close to that of petroleum-based diesel.

Biofuels not only substitute for petroleum but they also can have beneficial impacts on climate change. Ethanol and biodiesel are produced within a relatively closed carbon cycle where carbon dioxide (CO_2) released into the atmosphere during combustion is recaptured by the plant material and used to produce additional fuels. To the extent these biofuels displace petroleum, they reduce CO_2 emissions and therefore are more climate-friendly than petroleum.

However, crops must be cultivated to provide the needed feedstock and then processed to produce the fuels. Cultivation and processing involve the use of energy and other inputs, such as fertilizer, that can have negative effects on greenhouse gas emissions and other environmental impacts, like water pollution.

A full production-cycle analysis is needed to make definitive statements regarding the positive climate impacts of large-scale biofuel production. Careful studies put the "well-to-wheels" greenhouse gas benefits of corn ethanol at about a 20-percent reduction and cellulosic ethanol at about an 80-percent reduction relative to gas derived from conventional oil.

Carbon-Free Cars

To some, transportation nirvana involves not ICEs, but electric cars running on storage batteries or electricity generated from on-board, hydrogen-powered fuel cells. If ICEs have a role in this utopia, it is in the form of plug-in hybrids—electric cars with sizable on-board battery storage and ICEs to either recharge the batteries or, when needed, provide power directly to the wheels. In either case, the extent to which these alternatives affect our reliance on petroleum again depends on their relative cost with respect to petroleum and biofuels and their acceptability in eyes of the consumers.

Battery-powered pure electric (as opposed to plug-in hybrids) and fuel cell–powered electric vehicles cannot, at present, compete on price and attributes with ICE-powered vehicles. Battery-powered vehicles are much closer to commercial production than fuel-cell vehicles, but as yet none of the major manufacturers have committed to large-scale production (although some small-scale production by start-up companies is expected).

If the goal is to reduce U.S. petroleum consumption over the next decade or two, battery-powered electric vehicles may play a role, but the size of that role depends, as it has in the past, on advances in battery technology. Fuel-cell vehicles must overcome larger engineering problems, including hydrogen storage and development of a safe hydrogen-delivery infrastructure, before they are ready for any widespread commercial deployment.

The bridge between internal combustion engines and an automotive future that doesn't rely solely on petroleum might be the plug-in hybrid that uses grid-charged batteries for short trips (of 50 miles or less). However, the plug-in hybrid still faces the same battery issues that have plagued electric-car development, namely weight, range, and cost. *The New York Times* reports that Toyota has a plug-in hybrid ready for the market—only time will tell.

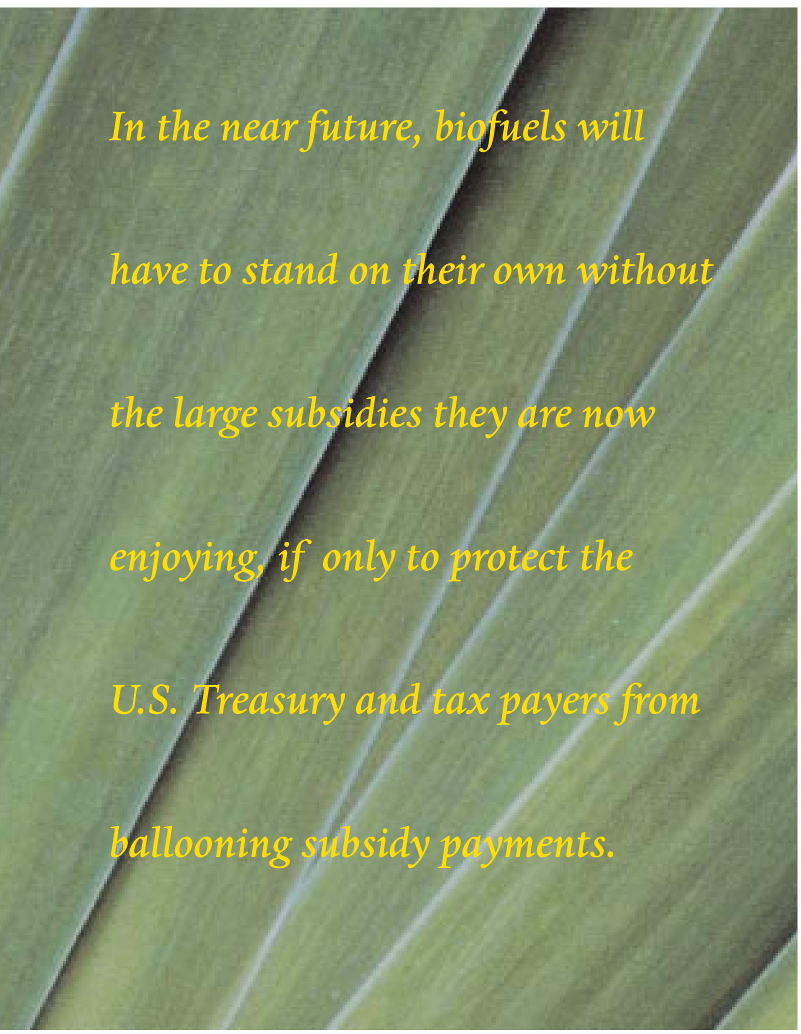
Sticks and Carrots

Government policy is often a combination of sticks and carrots (mandates and incentives), and this is true for biofuels and advanced vehicles. With respect to advanced vehicles, sticks (mandates) applied to vehicle manufacturers come in the form of regulations like the California Zero Emission Vehicle (ZEV) mandate, which directed automakers to produce specific quantities of electric cars starting in 2003 but has been modified over the years due to litigation. Carrots (incentives) come in the form of tax credits to consumers. For example, tax credits ranging from $400 to $3,400 were available for purchasers of all new hybrid vehicles, but upper limits on government funds available for such credits mean that for certain hybrids (notably the Toyota Prius) funds will soon be exhausted. Tax credits up to $4,000 are still available for purchasers of new pure electric cars that run on batteries or electricity from hydrogen fuel cells. The idea behind both sticks and carrots is to develop a market for these vehicles in the hopes that increased production will lead to lower costs, making these vehicles competitive with ICEs.

Government biofuel policy is also composed of incentives and mandates designed to establish markets and increase domestic production. The most important mandate is the recent renewable-fuel standard contained in the 2005 Energy Policy Act requiring that 2.78 percent of the gasoline sold or dispensed in calendar year 2006 be renewable. There is good reason to believe this target will be met if not exceeded. Incentives are provided through provisions of the 2002 Farm Bill encouraging the production of biofuels through small grant programs, the subsidies provided by the Commodity Credit Corporation (discussed previously), and 2005 Energy Policy Act's provision of additional subsidies to domestic ethanol and biodiesel producers

One can't know for certain how effective incentives—in the form of purchase subsidies—have been at spurring hybrid, pure electric, and fuel-cell vehicle sales. However, it seems likely that although hybrid sales have benefited from the credits, consumer satisfaction with the vehicles, combined with fear of ever-higher gasoline prices, has been a substantial motivator. Similarly, it is doubtful that continued credits will do much to build consumer demand for pure electric and fuel-cell vehicles until those vehicles meet customer demands and gasoline prices remain high. What is needed is breakthrough battery technology; any government policy that can accelerate the attainment of this goal will have a significant effect on the commercialization and penetration of these vehicles.

Subsidies have no doubt been instrumental in the growth of biofuel production. The issue facing policymakers now is whether these subsidies will be necessary in the future, how they can be set in some optimal sense (that is, as low as possible to achieve the desired result), and how can they be removed or reduced given the political constituency they have developed.



Second-Best Alternatives

The key rationale for reducing petroleum consumption lies in the fact that the market price does not account for its full social cost: the negative externalities or consequences associated with petroleum use—such as greenhouse gas emissions and national security issues—are not incorporated in the market prices.

For economists, the standard policy response to these externalities is the imposition of a tax equal to the marginal value of the externality so that the market price would represent the full social cost of petroleum consumption. The policies discussed above are second-best alternatives to a tax policy and therefore will be less efficient than a tax (perhaps by a wide margin). Given the lack of political will to impose taxes on petroleum, second best may be all we have at the moment, but that is no reason to cease striving.

Even in a second-best world, some policies are better than others. In the case of biofuels, we are concerned with their continued commercialization, the establishment of a robust market for them, and the growth of delivery infrastructure. In the case of new motor technologies (all electric or fuel-cell cars), we are concerned with continued technology development in this pre-commercial phase. Subsidies and mandates are better suited to commercialization, while policies focusing on R&D are better suited pre-commercialization.

In the near future, biofuels will have to stand on their own without the large subsidies they are now enjoying, if only to protect the U.S. Treasury and taxpayers from ballooning subsidy payments. At the very least, the corn-ethanol subsidy should be phased out, as well as the import restrictions. ■