Promoting Bio-Ethanol in the United States by Incorporating Lessons from Brazil's National Alcohol Program

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Abstract

Current U.S. energy policy supports increasing the use of bio-ethanol as a gasoline substitute, which Brazil first produced on a large scale in response to the 1970s energy crises. Brazil's National Alcohol Program stood out among its contemporaries regarding its success at displacing a third of Brazil's gasoline requirements, primarily due to favorable market conditions and government support. Similar to the Brazilian experience, future progress towards displacing gasoline with fuel ethanol in the U.S. will depend largely upon political support and economic circumstances in the agricultural and energy sectors and markets. Accounting for differences in aggregate gasoline usage and feedstock availability compared to Brazil, the United States would have to speed up commercialization of cellulose ethanol technology in order to achieve a similar degree of success as Brazil, support co-production of biomass derivatives along with fuel ethanol production, and maintain profitability of innovation in the bio-ethanol sector, among other initiatives.

Introduction

Recently, the U.S. government has expressed strong interest in fuel ethanol due to prospects of declining petroleum supply in conjunction with increasing global energy demand. Among countries with active bio-fuels programs, Brazil was exceptional among them given that its government incorporated bio-fuels as a significant component of its energy portfolio. The success of its alcohol fuels program, *Programa Nacional do Alcool* (eng. the National Alcohol Program, also known as PNA or Proàlcool), has depended largely upon government, private, and other economic incentives. Heavy governmental involvement in Brazil's economy facilitated means of achieving the PNA's objectives, even when economic circumstances did not prove conducive towards bio-fuel implementation. Brazil's successes and failures with promoting alcohol fuels during the 1970s and 1980s serve to guide American development in sustainable energy sources in the near future. In the United States, ethanol production targets would have to increase by greater margins than the currently mandated increases, which would mean speeding up commercialization of biomass ethanol technology in addition to increasing corn yields and ethanol production efficiency. Meanwhile, building bio-refineries that produce marketable co-products along with ethanol would reduce production costs, enabling ethanol to compete more effectively against gasoline.

Summary of Brazil's experience with alcohol fuels

Brazil's PNA has demonstrated through its National Alcohol Program that increasing bio-fuel production and usage is feasible, though uneconomical except when petrol prices rise high enough. High feedstock costs, which accounted for 57.0 percent of the total cost of producing alcohol from sugarcane, also reduced economic viability of bio-fuels (Rothman, 1983, 114). As sugar prices increased through the 1980s and late 1990s, converting cane into ethanol yielded less foreign exchange savings from energy import substitution than the surplus gained from sugar exports. Presently, high petroleum prices and speculation of higher prices in the future are providing incentive for both the Brazilian and U.S. governments to support their bio-fuel sectors.

Recent developments in the U.S. ethanol sector and comparison with Brazil's ethanol industry

Background

Even with similar policies compared to Brazil's under its military regime, the United States must

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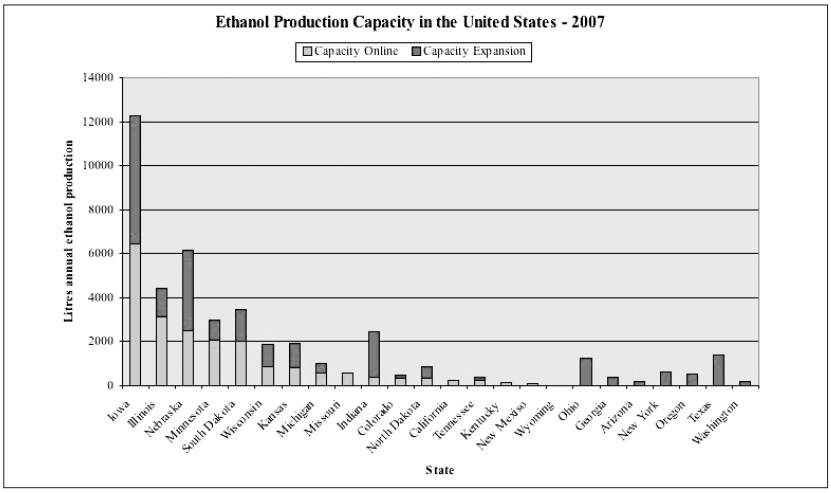
apply more effort to achieve a similar degree of success at displacing petroleum. This is because annual gasoline consumption in the United States, which was 516 billion liters as of 2004, dwarfs Brazilian gasoline consumption by 20-fold (Yacobucci, 8; Des Moines Register). Unlike Brazil's situation, use of sugarcane to produce bio-fuels in the United States would result in selling prices too high to compete with petrol, without heavy subsidization. Sugar tariffs against foreign producers contributes to heightened costs of producing ethanol from sugar in the United States, rendering ethanol production from sugar uncompetitive against both corn ethanol production and petroleum imports at low-season prices.[1] Furthermore, importing cheaper cane-based ethanol from Brazil would undermine the efficacy of import substitution policy, which Brazil pursued with its commitment to bio-ethanol. Instead of reducing total energy imports, the United States would be merely transferring its foreign energy dependency from Middle Eastern petroleum companies to Brazilian sugar interests.

Energy market conditions

Though they have declined from near record highs during the summers of 2005 and 2006, current and projected future petroleum prices are high enough for ethanol to be price-competitive. This includes higher-cost ethanol produced in the United States, where tariffs against foreign producers except for Caribbean Basin Initiative members have kept low-cost ethanol from Brazil and other developing nations out of the U.S. liquid fuels market. Brazilian ethanol exports, for instance, receives a 20 cent import duty that increases its final price to levels comparable with those of U.S. domestic corn ethanol. However, in 2006, the U.S. Renewable Fuels Association reported that the United States imported nearly two billion liters of ethanol, two-fifths of which originated from Brazil (18). Demand had been sufficiently high enough to provide foreign ethanol producers a competitive export market.

The ethanol industry is among the fastest growing of all renewable energy industries, and its growth has shown no signs of abating. Existing plant expansion and new plant construction will nearly double ethanol production capacity by 2009, as illustrated in Figure 1.

Fig. 1



Source: RFA (2007), 3.

In the meantime, prospects of carbon emission caps and taxes in the near future should make investment in bio-fuels more lucrative. Comparatively, combustion of E10 gasoline produces 6 to 10 percent less greenhouse gas (GHG) emissions compared to combustion of pure gasoline, and combustion of E85 produces up to 80 percent less GHG emissions, depending upon how much fossil fuel was used for its production and transport.

Recommendations for future fuel ethanol policy

Currently, ethanol pump prices undercut gasoline prices by 25 percent, accounting for government subsidies and tax exemptions. However, a sudden drop in petroleum prices would diminish the competitiveness of fuel ethanol; this would likely occur as gasoline demand drops in response to increased availability of inexpensive bio-fuels. Keeping ethanol prices low enough to compete with petroleum at low import prices will prove crucial to maintaining a high production growth rate. In conjunction with lowering ethanol costs through innovation in processing technology, diversification of ethanol feedstock will dampen the volatility of ethanol prices, as they will not lose competitive-

ness against crude oil prices solely due corn price fluctuations.

Challenges to implementation of current ethanol production technology
Among the most pressing issues facing expansion of the corn-ethanol industry, diverting corn production towards the manufacture of fuel ethanol may raise food prices. Though production of sweeteners and other corn-based foodstuffs utilizes only 13 percent of U.S. corn output, over 50 percent of current output goes toward feeding livestock, especially beef cattle. To illustrate the great likelihood that continuing a corn-based fuel ethanol program would raise food (particularly meat) prices, ethanol plants consume 12 percent of current U.S. corn production for displacing three percent of the 560 billion liters of motor gasoline consumed in the United States annually. High corn prices would also raise ethanol prices, thus diminishing its competitive advantages over petroleum as feedstock costs account for nearly 80 percent of its selling price.

Initiatives

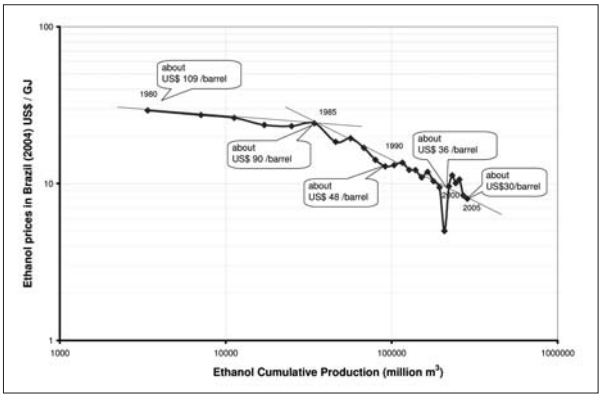
Increasing blending ratio of ethanol to gasoline
E85 or pure ethanol would substantially reduce foreign energy imports only if ethanol distribution facilities become widespread. To limit expense due to infrastructure adjustment, refiners should substitute ethanol-blended gasoline for pure gasoline, increasing ethanol volume percentage as ethanol production increases.[2] Gasoline engines without modification are capable of running on ethanol-gasoline mixtures of up to 25 percent ethanol by volume, without significant detriment to performance.[3] In Brazil, such mixtures are the standard for dispensing at all filling stations. Blending ethanol into gasoline by a 1:3 ratio would ensure displacement of a quarter of U.S. gasoline demand, without great need to modify infrastructure. At current prices, a 25 percent ethanol blended fuel would cost roughly the same as pure gasoline per unit energy; widespread availability of biomass ethanol would reduce costs relative to pure gasoline.

Accelerating commercialization of biomass ethanol
Crop residue and other cellulose plant matter, when converted into ethanol, have the potential to displace the entire current U.S. gasoline requirements. United States Department of Agriculture and Department of Energy [DOE] estimates deem a 30 to 40 percent displacement as a realistic target. A major drawback, present costs for cellulose conversion run over 60 cents per liter of ethanol, more than twice the cost of producing ethanol from corn. However, the DOE is aiming to reduce production costs to below 16 cents per liter by 2015 (DiPardo, 2002, 1). Such production costs will create an economic advantage for ethanol against petroleum at prices as low as 25 USD per barrel, probable once availability of biofuels is able to reduce petroleum demand significantly.

Implementation of biomass ethanol, however, will not be without significant risk as in the case of Brazil's PNA in its early years.[4] Sudden shifts in government policy due to fluctuations in the energy market, especially drops in petrol prices, could render a bio-refinery economically nonviable. At present, high costs of producing ethanol from biomass would compound difficulties wrought on by significant declines in the price of crude oil. Therefore, only when biomass technology matures should the U.S. government consider incentive reductions, with maturity defined as having successfully become a major permanent component (supplying 20 to 50 percent of transport fuels) of the U.S. transport fuels portfolio. This would mirror the subsidy cuts of the Brazilian government when ethanol maintained its 30 to 40 percent contribution to Brazil's transport fuel requirements. Lack of subsidies has not prevented the now-mature Brazilian ethanol industry from experiencing steady growth in recent years; production increased from about 15 billion liters in 2003 to 17 billion liters by 2006 (Martines-Filho, 2006, 91; RFA, 2006, 16; 2007, 18). In Brazil, ethanol prices actually declined at a faster annually compounded rate after direct industry subsidies ended in 1985 while production continued at a relatively stable volume between 11 and 14 billion liters annually, as shown in

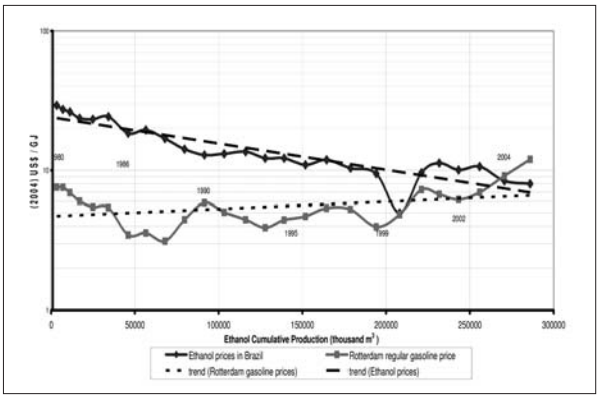
Figures 2 and 3. As of 2005, ethanol prices in Brazil significantly undercut gasoline prices for the first time since the early 1980s, this time with less subsidization.

Fig. 2:
Ethanol prices in Brazil by gigajoules (GJ) energy and volume from 1980 to 2005.



Source: Goldemberg et al (2003), 5, as cited in Goldemberg.

Fig. 3:
Ethanol prices in comparison with gasoline prices in Brazil



Source: Goldemberg et al (2003), 8, as cited in Goldemberg.

When direct subsidies for ethanol producers in Brazil fell out of favor in 1985, the Brazilian ethanol industry had already succeeded in displacing over a third of gasoline demand. It no longer depended on government support as high consumer demand sustained sales even without subsidies (though pump price controls were still in place), while ethanol motor vehicles had saturated the new vehicle market, accounting for over 90 percent of new passenger auto sales. In addition, dismantling the National Alcohol Program would have proven prohibitively expensive, as cane distilleries had become an integral component of Brazil's energy, agricultural, and chemical production landscape. Contrarily, U.S. ethanol output has displaced barely five percent of gasoline demand. Given that it is still an emerging industry whose progress would be largely determined by future government policy and energy prices rather than a "permanent" energy products sector, government financial support is still necessary to ensure future economic viability.

Regardless of whether fermentation technology for cellulose ethanol advances quickly enough for a high degree of market penetration in the near-term, increasing the efficiency of refining processes will improve market penetration by reducing the process margin and thus the selling price for ethanol (NREL, 2005, 21). Process margin includes all variable costs other than purchased external energy and feedstock costs, such as waste disposal, labor, and overhead costs. Again, an increase in R&D funding for bio-fuels will provide refiners the ability to adopt processing technologies that are more efficient but demand a greater initial investment compared to existing technologies.

Cogeneration

Since the 1980s, Brazil's bio-fuels industry has been taking advantage of ethanol distillery by-products to maximize returns on investment. For example, the direct burning of bagasse, fibrous cane residue after juice extraction, has powered distillery processes and therefore reduced distilleries' need to use fossil fuels. This has augmented Brazil's efforts to curb dependency on imported petroleum and to reduce greenhouse gas emissions, which would be an estimated 25 percent greater than at present without a bio-ethanol program.

Power generation applications would also function well for U.S. ethanol bio-refineries. Fermentation

residues could replace fuel oil and natural gas that currently power refinery processes, which would both augment substitution of imported fuel and reduce net greenhouse gas emissions from fossil fuel combustion. Powering refineries with electricity from wastes will reduce processing cost of ethanol by at least 10 cents per gallon, or 2.6 cents per liter (Lynd et al, 2005, 10). This cost advantage, determined from 2002 energy price data, has since increased due to rising external energy prices. Moreover, increases in biomass-to-ethanol conversion efficiency would permit greater peak processing capacity for the same total energy consumption. As a result, savings from cogeneration, in proportion to cost of producing ethanol only, will increase from 20 percent to nearly 40 percent of production costs.

Co-products as a means of cost reduction

The United States ethanol industry has adopted and should continue to adopt the use of by-products and wastes in lowering production costs. Government subsidies and incentives not necessary in this regard, as sales of ethanol co-products will add to the cost advantage of ethanol against petroleum fuels.[5] Sugarcane distilleries in Brazil produce wastes known as vinhoto, plant residue left over after alcoholic fermentation of sugarcane. In the past, this waste was routinely dumped into waterways, but it now serves as a fertilizer for sugarcane plantations (Oliveira, 2002, 136).[6] Likewise, U.S. ethanol producers have been selling corn grinding and fermentation wastes as livestock feed to generate the most revenue per unit feedstock. While its by-products prove valuable to agriculture, production of ethanol also produces co-products valued by chemical manufacturers, such as succinic acid, lactic acid, and furfural. Selling ilimited quantities of these high-value chemicals generates significant revenue that will permit lower selling prices for ethanol.

Diversifying the product slate for ethanol production will help ensure economic viability for refiners in the event of market downturn. In Brazil, where producers could switch between sugar and ethanol production at annexed distilleries, ethanol market downturn in the 1990s led distillery operators to shift towards sugar production; sugar prices were also more favorable to ethanol prices at that time. Petroleum refineries already incorporate a diversified product slate selection, producing more gasoline in summer months in response to high driving demand and more fuel oil in winter months in response to high heating demand (Lynd et al, 2005, 22).

Conclusions

Through policies that support ethanol industry innovation and enlargement, the United States is capable of achieving comparable success to that of Brazil in displacing petroleum consumption. However, the United States must conduct such an endeavor on a scale never before attempted. With steadily increasing demand for gasoline, already the highest in the world on a per capita basis and over ten times that of Brazil, more rapid advances in bio-fuel production and technology shall prove necessary in the future. Despite this crucial difference, U.S. consumption of fuel ethanol and other bio-fuels will increase appreciably if costs of these fuels undercut costs of petroleum, especially without heavy subsidization. This situation of favorable costs, already present today but less certain past the immediate future, can be maintained via following key policies undertaken in Brazil in the aftermath of the 1970s energy crises. Until the U.S. ethanol industry penetrates the liquid fuels market sufficiently so that it becomes a permanent component of its transport energy portfolio, like the current situation in Brazil, at least some degree of government support to encourage innovation by the private sector will be important to the industry's long-term survival.

Footnotes

1. Producing ethanol from sugarcane or sugar beets would be profitable when gasoline sells for over 0.75 USD/liter, now typical for pump prices during summer months. At respective costs of 63 cents/L and 62 cents/L, however, cane or beet ethanol production would still cost twice as much as corn ethanol production (Shapouri, 2006, iv.).

2. By 2015, corn ethanol production of 57 billion liters per year will ensure adequate supply for

blending ethanol into all gasoline sold (10 percent by volume, same as the present ratio).

3. Ethanol only provides about 60-70 percent of the energy provided by gasoline but generates more power per energy unit equivalent due to leaner fuel-air ratios and greater octane values. Fuel intensity, or amount of fuel used per unit distance, does not correlate directly with an increase in ethanol's proportion of a gasoline-ethanol fuel mixture; E85 provides 30 percent less energy per unit volume compared to gasoline, but fuel intensity of vehicles running on E85 increases less than is what is expected based on energy density difference alone.

4. During the late 1970s in Brazil, the Ministry of Mines, national financial institutions, and Petrobras, then the sole distributor of liquid fuels, opposed the National Alcohol Program due to concern over high costs of producing ethanol in comparison to petroleum refining costs.

5. No regulation that mandates a minimum amount of waste re-use exists on the federal level in the United States.

6. Cane plant residue will cause soil contamination if applied on plantations other than its plantation of origin.

Acknowledgements
I would like to thank my mentor, Dr. Joshua Linn of the Department of Economics at the University of Illinois at Chicago, for his support of the work reported herein. For a complete bibliography, contact the author at yangbodu@imsa.edu.

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