Once a commercially viable demonstration facility is proven to work, the next stage is to embark on the deployment of the **first commercially viable plant**. This is the stage at which developers need to secure an investment-grade EPC (Engineering, Procurement and Construction) contractor, finance engineering and construction (assuming non-recourse financing), finalize input and offtake contracts for the life of the facility debt, and have secured appropriate equity commitments from investors. It is the point at which capital demands are typically highest because investors still see high construction risk even for a demonstration-proven technology that is now being scaled up. By the construction stage, financing needs to be secured through an investor or private bank.

A modified loan guarantee program run by DOE to cover the construction period and the early years of operation was discussed among the experts and deemed to be ineffective unless it met certain criteria. First, any loan guarantee program must be limited to a finite period of time that will only provide guarantees during the project's riskiest periods. This time period must be set prior to the distribution of the loan. The loan guarantee must be gradually reduced and expire prior to the loan's payoff. In addition, the loan guarantee should be contingent on the review and approval of a team of independent engineers and financial consultants. The purpose of the review is to assess the technology and business plan to ensure that the loan will in fact help guarantee the successful and profitable launch of the technology. Furthermore, financial information needs to be reviewed to ensure that the project's cost has not been escalated solely to reduce entrepreneurial risk. The loan should account for only the construction and startup costs of the technology in accordance with good engineering practices. The objective of the loan guarantee should be to ensure the technology meets its performance criteria. Ultimately, the loan should cover approximately the first one to two years of the technology's deployment, following successful attainment of the performance guarantees, and should then gradually decrease in its coverage ratio over time. It is anticipated that the coverage ratios would shrink to zero at sometime between five and ten years following the passage of the performance criteria.

Another feasible solution would be for DOE to create a last resort risk mitigation pool for biomass technology developers, looking to other successful Federal programs, like the Transportation Infrastructure and Innovation Act (TIFIA), as a model. This would allow DOE to provide incremental financial guarantees during the commissioning and performance acceptance stages of the project through the first year of operation, thereby enabling developers to raise the necessary capital to proceed with development of their new biomass technology. This program could only be accessed when all other remedies have been exhausted and when the corrective action will result in a successful commercial launch. It was felt that a risk mitigation pool coupled with a successful demonstration project would be adequate to ensure successful deployment of the technology. However, a risk mitigation pool can also be used with a loan guarantee program to further accelerate technological deployment.

DOE would assess the level of severity of a given deployment barrier, assess the worthiness of the recipient, and issue financing. The developer would be required to pay a fee for the insurance guarantee including repayment of any draw on that insurance policy by a given period of time (typically following deployment). The money from the insurance premiums would be recycled back into the insurance program. Developers who apply to access the insurance program would first have to be approved by a team of independent engineers who determine whether the technical problem was unavoidable and then outline a cost estimate. Assistance would only be provided after a solution has been identified and reviewed by independent engineers.

Due to the considerable time, money and effort already invested in most of these projects, it is in the best interest of all parties (entrepreneurs, investors, contractors, markets, etc.) to overcome these hurdles and deploy these technologies. These suggested federal insurance guarantees should allow developers to successfully deploy their product and begin realizing revenue streams that not only support operations, pay debt service but also provide solid equity returns to their investors.

Table 1

Possible U.S. DOE Deployment Solutions
• Continue to provide 80/20 funding of technology development (**Current**)
• Continue to provide 50/50 funding of small-scale pilot-tests (**Current**)
• Provide 20/80 funding of critical large-scale demonstrations (**New**)
• Establish a loan guarantee program (**New**)
• Establish a pool for risk mitigation (**New**)

The recommendations in this document outline some logical steps to facilitating biomass technology deployment. Although DOE invested $93.9 M in biomass technology R&D in 2004, it is the fundamental objective of OBP to see that these technologies are ultimately deployed and "directly contribute to the creation of a new bioindustry to help reduce U.S. dependence on foreign oil by supplementing the use of petroleum for fuels and chemicals." Research and development issues have traditionally been the primary focus of DOE assistance and funding. However, it is clear that focusing on R&D alone will not lead to successful deployment.

The need to diversify the U.S. energy portfolio and to create a bioindustry as a means to this end is the reason these financial barriers must be addressed. Biomass clearly represents a viable option for displacing U.S. petroleum reliance, and these recommendations could be the next steps to ensuring its successful integration into the U.S. energy market.

Note: The information contained in this paper was derived from a white paper which was developed by members of USDOE's Office of Biomass Program and outside professionals, including the author, with expertise in project finance.

Ethanol: Lessons from Brazil

By David Sandalow

Ethanol is hot. In the United States, production increased by more than 20 percent in 2005. The nation's 97 ethanol plants are operating at close to full capacity, with another 33 plants under construction. Politicians from President George W. Bush to Senator Richard Lugar to Senator Barack Obama to Democratic National Committee Chair Howard Dean all support aggressive programs to promote ethanol.

Yet today ethanol provides only about 3 percent of the United States' transportation fuel. Few experts expect this figure to increase to more than 7 percent by 2010. In Brazil, in contrast, ethanol provides more than 40 percent of the fuel for transportation. Flex-fuel cars – capable of running on gasoline or ethanol – grew from less than 1 percent of the Brazilian new car market in 2001 to more than 70 percent today.

As the United States explores ways to reduce oil dependence, many observers are looking south for guidance. This paper summarizes the history of the Brazilian ethanol program, describes the program's current status and considers lessons for the United States from the Brazilian experience.

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History

The early 1970's were a boom time in Brazil, with many observers heralding the "Brazilian economic miracle." Yet President Ernesto Geisel faced twin problems. First, the cost of Brazil's oil imports tripled in late 1973, due to the Arab oil embargo. Second, world sugar prices, which had been climbing upward since the mid-1960's, declined sharply in 1974.

Faced with these problems, Geisel launched the Brazilian National Alcohol Program in late 1975. The program was intended to reduce the need for oil imports and provide an additional market for Brazilian sugar. As a first step, the federal government immediately began promoting the production of ethanol for blending into gasoline, to the maximum extent feasible in existing vehicles (approximately 20 percent by volume).

In promoting ethanol, Geisel's government had many tools at its disposal. (Brazil's government during this era was both a central player in the nation's economy and a military dictatorship.) First, the government offered credit guarantees and low-interest loans for construction of new refineries. Second, a state trading enterprise began purchasing ethanol at favorable prices. Third, gasoline prices were set to give ethanol a competitive advantage. Fourth, a marketing program was launched, with the slogan "Let's unite, make alcohol." Finally, the state-owned oil company, Petrobras, began making investments for distribution of ethanol throughout the country.

The results were dramatic. Between 1975 and 1979, ethanol production increased more than 500 percent.

A second stage of the program was launched in 1979, when the Brazilian government signed agreements with major car companies to install assembly lines for 100 percent ethanol cars. Participating companies – including Fiat, VW, Mercedes-Benz, GM and Toyota – agreed to produce 250,000 ethanol-only cars in 1980 and 350,000 in

1982. A government program provided taxi drivers with incentives to convert their cars to 100 percent ethanol. Several leading race car drivers made highly visible use of 100 percent ethanol cars.

During the early 1980's, the Brazilian ethanol program flourished. With the help of government pricing policies, which kept the cost of ethanol to consumers significantly cheaper than the cost of gasoline, ethanol production more than tripled between 1979 and 1985. A World Bank loan helped cover costs of the program. By the mid-1980's, ethanol made up roughly half of Brazil's liquid fuel supply.

In 1985, however, Brazil's ethanol program began to experience problems. World oil prices dropped sharply in 1985-86, reducing the immediate benefit of replacing oil imports with ethanol. At the same time, Brazil faced serious inflation problems and began a series of difficult economic reforms. As part of a broader cut back on subsidies, the price differential between ethanol and gasoline was eliminated, soft loans for the construction of new refineries were cut, and support for the ethanol program from state trading companies was slowed and then stopped.

These changes had a significant impact on ethanol production, which stagnated. By the late 1980's ethanol production even began to decline slightly, as world sugar prices rose and export markets for refined sugar became more profitable.

Yet these trends in ethanol production had little immediate impact on Brazilian automakers, which continued to manufacture ethanol-only cars in increasing amounts. By the late 1980's, almost all new cars in Brazil were made to run on ethanol only. The result was a serious shortage of ethanol in 1990. In a rich irony, Brazil was forced to import ethanol and turn to methanol blends to keep cars on the road.

Political support for the ethanol program evaporated. Brazilian auto manufacturers quickly retooled to build gasoline cars. By the mid-1990's, only fleet vehicles (such as taxis and rental cars) were being made to run on ethanol.

The 1990's were a quiet decade for Brazil's ethanol program. With deregulation and privatizations underway throughout the Brazilian economy, and world oil prices low, there was little political support for returning to programs of the kind that helped build Brazil's ethanol infrastructure during the 70's and 80's. Nevertheless, throughout this period, the national government continued to require that all gasoline sold in Brazil contain roughly 20 percent ethanol by volume.

As the decade progressed, some Brazilian engineers and policymakers showed increasing interest in flex-fuel vehicles of the kind being built by U.S. manufacturers seeking credits under the CAFE law. Toward the end of the 1990's, several auto manufacturers began talking with the Brazilian government about manufacturing flex-fuel vehicles for the Brazilian market.

In 2001, the Brazilian government agreed to treat flex-fuel vehicles as ethanol-fueled, entitling FFV's to preferential tax treatment (a 14 percent sales tax, as compared to a 16 percent sales tax on non-ethanol cars). Ford launched the first flex fuel prototype in 2002, with VW following in 2003.

Brazilian Ethanol Program Today

Today ethanol provides roughly 40 percent of transportation fuels in Brazil, a higher percentage by far than in any other nation. In 2005 Brazil produced just over 4.23 billion gallons of ethanol, roughly the same as the United States (which produced 4.26 billion gallons).

The most dramatic development in the Brazilian ethanol program in recent years has been the explosive growth of flex-fuel vehicles. In November 2004, FFV's represented 30 percent of new car sales in Brazil. For calendar year 2005, the figure was 53 percent. In February 2006, more than 70 percent of new cars sold in Brazil were flex-fuel.

Production costs for ethanol in Brazil are the world's lowest. UNICA, the industry trade association, estimates average production costs of approximately US$0.80 per gallon. (Estimates of costs in the U.S. vary from US$0.90 - US$1.30 per gallon.) A favorable climate, low labor costs and mature infrastructure built up over several decades are among the factors producing this advantage.

The Brazilian government's principal intervention on behalf of its ethanol industry is the requirement that all gasoline sold contain a minimum percentage of ethanol. This blending ratio is currently set at just over 20 percent. In addition, the government provides a slight tax preference for the purchase of new flex-fuel cars (14 percent sales tax, as compared to a 16 percent sales tax on gasoline-only vehicles, as noted above). Brazil maintains a 30 percent tariff on imports of ethanol and 20 percent tariff on imports of sugar. Government price-setting for ethanol in Brazil was phased out during the 1990's.

Brazil is currently courting export markets for ethanol, focusing on Asia and North America. Petrobras recently signed a deal with Mitsui to pursue study ethanol logistics for the Japanese market.

The ethanol industry enjoys widespread political support in Brazil today. The industry takes credit for more than 1.8 million jobs in Brazil and for replacing, since 1976, more than 1.44 billion barrels of oil. Brazilian ethanol refineries generate their own process heat and electricity from portions of the sugar crop known as "bagasse," with many refineries selling surplus electricity into the grid. Ethanol contributes significantly to improving air quality in Sao Paolo and to cutting emissions of heat-trapping gases from the Brazilian transport sector.

In March 2006, ethanol prices reached record highs due to sharp increases in global prices for refined sugar. In response, the government reduced the mandated blending ratio from roughly 25 percent to 20 percent. Possible supply shortages are looming, as sugarcane growers divert ethanol feedstock to the refined sugar market. With oil prices also reaching record highs, market analysts differ with regard to likely growth trajectories for Brazil's ethanol industry in the months and years ahead.

Lessons for United States

Brazil and the United States share many characteristics. Both are continent-sized countries. Both are agricultural powerhouses. Both have mature domestic automobile industries.

There are many differences between the two countries, of course. Brazil's climate is warmer. Brazil's wage rates are lower. Cultural attachments to the automobile are different in each country. Brazil's government, until recently, owned key industries and set prices throughout the economy.

With these comparisons as background, what lessons can the United States draw from Brazil's ethanol program? I suggest five.

First, rapid expansion of ethanol production capacity is possible with government support. Matching the growth rates in the Brazilian industry during the 1970's – when ethanol production grew 500 percent from a small base in just a few years – is not a realistic objective. But the Brazilian experience suggests several policy tools that could be used in the U.S. today. Credit guarantees and low-interest loans such as those used in Brazil could help speed construction of the first generation of commercial cellulosic ethanol plants. (The Energy Policy Act of 2005 includes authorization for such programs, though Department of Energy guidelines and appropriations are needed to make those programs a reality.) Mandates for blending ethanol into the fuel supply – part of the Brazilian program since its inception – can provide powerful signals to producers and help promote rapid growth in capacity.

That said, we should be careful in drawing conclusions about rapid supply expansion from the Brazilian experience of the 70's. Several subsidies provided by the Brazilian government in that era – such as infrastructure investments by a state-owned oil company – could not be duplicated in the U.S. today. Rather than look for ways to duplicate policies of the Brazilian government 30 years ago, we should identify the specific objectives of those policies and ask how these objectives could best be achieved under current conditions. In the absence of a state-owned oil company, for example, how should the cost of converting distribution infrastructure (such as service station tanks) best be funded? If promoting rapid expansion of ethanol consumption is our larger goal, we need to devise a uniquely U.S. answer.

A **second** lesson from Brazil – consistency counts. Perhaps the most important part of Brazil's ethanol program over the past three decades has been the requirement that ethanol make up a certain percentage of the fuel supply. The Brazilian government has used this requirement to help control the ethanol market, varying the percentage somewhat depending on market conditions. Yet even during periods of relatively modest political support for the ethanol program, such as the 1990's, the requirement did not disappear. This was important in sustaining the industry through hard times.

A **third** lesson – any ethanol program must anticipate commodity price swings. Enthusiasm for ethanol is always highest when oil prices are high and sugar prices low. Yet the relative prices of oil and sugar will vary with time.

One essential way to prepare for price swings is with flex-fuel vehicles. The explosive growth of FFV's in Brazil during the past few years is a hopeful sign – both about the ability of auto companies quickly to scale up production and the instant acceptance of such cars by consumers. Precisely because commodity prices will vary, as Brazil saw in the '80's, a vehicle fleet in which FFV's predominate is essential to a successful long-term ethanol program

Fourth, public attitudes change quickly. In the 1970's and early 1980's, enthusiasm for ethanol in Brazil was high. In the late 80's and early 90's, public support collapsed with astonishing speed amidst shortages in supply. In the past several years, enthusiasm climbed steeply with higher oil prices and flex-fuel cars. Policymakers should anticipate and plan for significant short-term swings in public attitudes on ethanol, in response to market conditions and other factors.

Finally, ethanol technologies improve steadily with time. This is true of almost all technologies, but the Brazilian experience of the past 30 years provides some compelling data when it comes to ethanol. Between 1975 and 2000, production of ethanol per hectare in Brazil more than doubled. During the same period, harvesting costs fell by half. We can anticipate similar improvements if the U.S. ethanol industry grows substantially – staying "hot" – in the years ahead.