José Goldemberg

The Brazilian Experience with Biofuels

Innovations Case Narrative

From a technical perspective, there is nothing new in the renewed interest in using biofuels in the internal combustion engines on our roads. In the late 1800s, Henry Ford used ethanol to drive automobiles and Rudolf Diesel used biodiesel from peanuts to drive trucks. But these fuels were replaced in the early 1900s by gasoline and diesel oil distilled from petroleum; they became cheap and seemingly inexhaustible in the United States and a few other countries with easy access to oil. Meanwhile biofuels, particularly ethanol (also an alcoholic beverage), were expensive and produced in minor amounts compared to the huge quantities needed for large vehicle fleets.

Oil-poor countries, including Brazil, had a different experience. Since 1920, Brazilians have conducted technical studies on ethanol-run vehicles, including racing cars; because ethanol works so well as a fuel it makes a good alternative to imported gasoline. In 1931, a Brazilian law required that all gasoline include 5 percent bioethanol from sugarcane and the government regulated prices to make it possible. Over the years the blend remained almost constant and was slowly raised to 7.5 percent. Such blends did not require changes in the engines. In the early 1970s, Brazil imported all of its gasoline and petroleum from abroad, at an annual cost of U.S. $600 million. In 1973, with the first oil shock, imports rose to more than $4 billion annually, contributing greatly to the deficit in hard currency and badly damaging the economy.[1]

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Given this situation, the representatives of the sugar producers proposed ways to reduce Brazil's dependence on imported oil by increasing the amount of ethanol in gasoline. This move also made use of the idle capacity in sugar refineries, which can easily be converted to produce ethanol, and today most can produce both sugar and ethanol. In November of 1975, as a result of those proposals, the federal government established the National Alcohol Program (PROALCOOL) by decree, and set production goals of three billion liters of ethanol by 1980 and 10.7 billion liters in 1985.

Earlier that year, President Ernesto Geisel had visited the Air Force Technological Center in São José dos Campos, São Paulo, and was very impressed by the work being done there by engineers, led by Urbano Ernesto Stumpf, on ethanol-fueled cars using hydrated ethanol (95.5% pure ethanol and 4.5% water). Important changes in the engine were needed to use that fuel, which required a compression ratio of 12:1, compared to 8:1 for regular gasoline. The higher compression ratio meant higher efficiency, which partly compensates for ethanol's lower energy content. Combining all these factors, 199 liters of pure (anhydrous) ethanol can replace one barrel of gasoline (159 liters).

> Today Brazilians are driving about 24 million automobiles. Most of the pure-ethanol cars on the road—2.8 million in 2000—have been retired. Already seven million flex-fuel cars are on the road and their numbers are increasing rapidly. Ethanol to supply these cars is produced in 414 distilleries, of which 60% are equipped to produce both sugar and ethanol. In 2007, production reached 22 billion liters.

This change to engines meant a drastic change in auto manufacture, but under government pressure, local carmakers adapted. Meanwhile, sugar producers welcomed these changes, which let them divert more sugarcane to ethanol production, and better face oscillations in sugar prices on the international market. Also enthusiastic were nationalistic elements in the government, who saw ethanol as an instrument of national independence—although Brazilian auto manufacturers could no longer export their cars. It was also a problem to drive Brazilian cars in neighboring countries (and even some states in Brazil) that did not have service stations selling hydrated ethanol. The production of these cars began in earnest at the end of the decade; between 1979 and 1985, they accounted for 85 percent of all

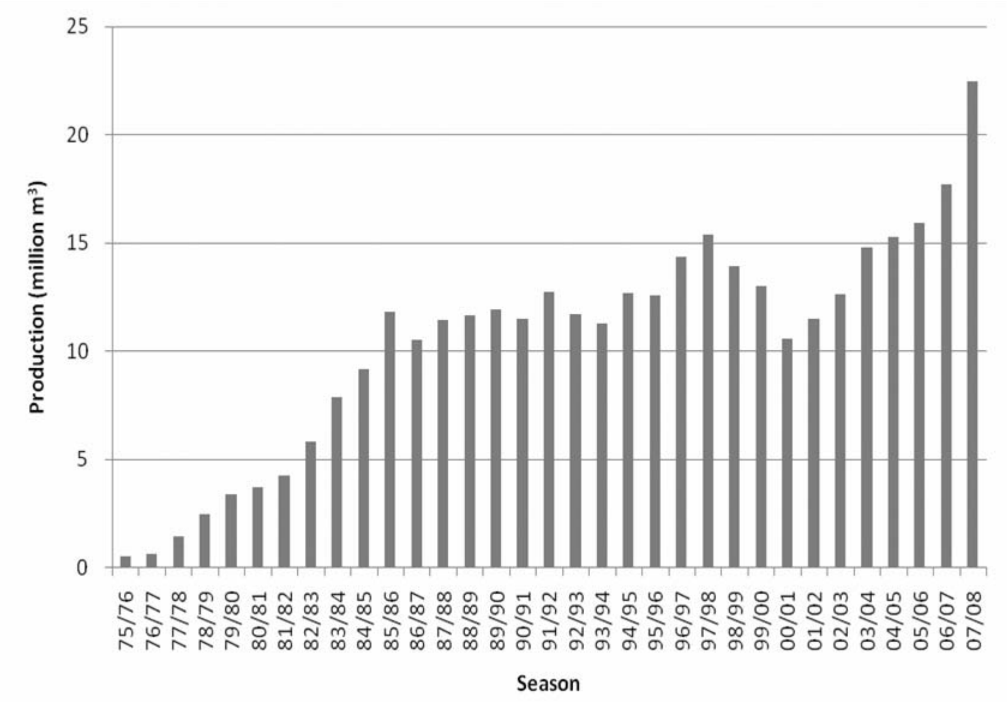


Figure 1. Evolution of Ethanol Production in Brazil.

Source: UNICA (Sugarcane Industry Association) statistical database.

http://english.unica.com.br/dadosCotacao/estatistica/.

new car sales.[2] Over the same period, the percentage of ethanol in gasoline reached approximately 20 percent.

Once ethanol was added to gasoline, MTBE (methyl tert-butyl ether) was eliminated as an additive: ethanol has a higher octane number than gasoline and performs the same role as MTBE. Soon, two fleets of automobiles were circulating in the country, with some running on gasoline, using a blend of up to 20 percent anhydrous ethanol and 80 percent gasoline, and others running entirely on hydrated ethanol. These goals were achieved through mandatory regulations and subsidies: Brazil was under an authoritarian government from 1964 to 1985.

In 1985, the scenario changed dramatically, as petroleum prices fell and sugar prices recovered on the international market. Subsidies were reduced and ethanol production could not keep up with demand. By 1990, sales of cars running on pure ethanol dropped to 11.4 percent of the total and continued to drop.[3] The production of ethanol leveled, off but the total amount being used remained more or less consistent because the blend was increased to 25 percent and more cars were using the blend (see Figure 1).

Then, after 2003, ethanol consumption rose again, as flexible-fuel engines were introduced in the cars produced in Brazil. These cars are built to use pure ethanol with a high compression ratio (approximately 12:1) but can run with any propor-

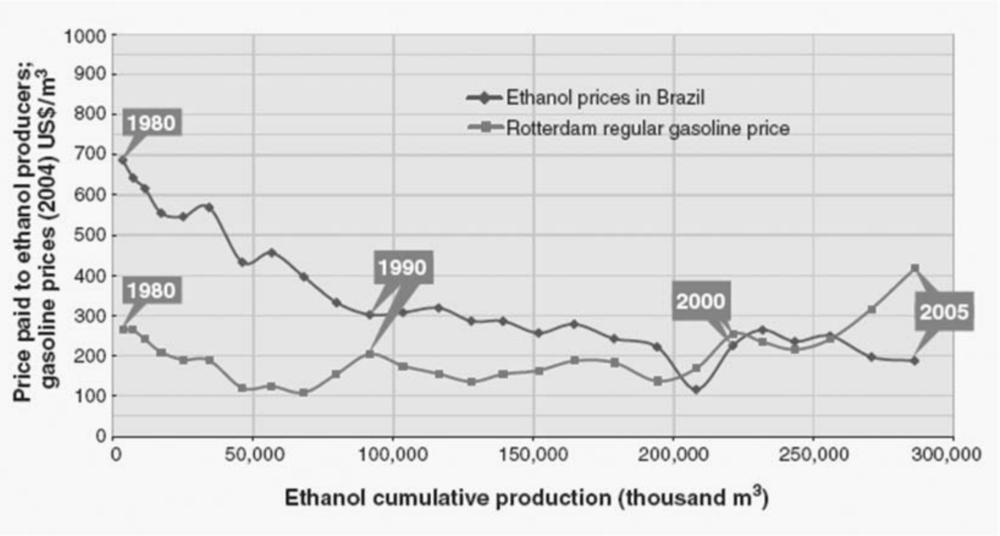


Figure 2. Economic Competitiveness of Ethanol Fuel Compared to Gasoline.

tion of ethanol and gasoline, from zero to 100 percent, as they have sensors that can detect the proportion and adjust the ignition electronically. Flex-fuel cars were an immediate hit; today they represent more than 95 percent of all new cars sold because they allow drivers to choose the cheapest blend on any given day.

Today Brazilians are driving about 24 million automobiles. Most of the pure-ethanol cars on the road—2.8 million in 2000—have been retired. Already seven million flex-fuel cars are on the road and their numbers are increasing rapidly.[4] Ethanol to supply these cars is produced in 414 distilleries, of which 60 percent are equipped to produce both sugar and ethanol.[5] In 2007, production reached 22 billion liters. For 2008 the estimated production was 26.1 billion liters; assuming that the recent growth of 8 percent per year continues, it should reach 30.5 billion liters in 2010, using an area of approximately four million hectares of sugarcane. In 2008-2009, 35 new distilleries were to start production, and another 43 are in various degrees of development. In 2015, production should reach 47 billion liters and the land required approximately six million hectares.[6] As Figure 2 shows, the cost of ethanol production in Brazil has dropped significantly over the years.[7]

In 1980, ethanol cost roughly three times as much as gasoline on the international market, but by 2004 technological gains and economies of scale had made it competitive with gasoline. Productivity has increased almost 4 percent per year for the last 30 years. The number of liters of ethanol produced per hectare of sugarcane harvested increased from 3,000 liters/ha to more than 6,000 liters/ha, and today ethanol is fully competitive with gasoline without any subsidies.[8]

What drove this extraordinary expansion of ethanol production from sugarcane? Economic and strategic factors were crucial in reducing Brazil's dependence on petroleum, but environmental issues are also key. Ethanol does not have the impurities that gasoline does, such as sulfur oxides and particulates, which are the

Figure 3. Location of Sugarcane plantations and Distilleries in Brazil.

Source: C. Macedo, 2005. *Sugarcane's Energy: Twelve Studies on Brazilian Sugarcane*. São Paulo: Berlendis & Vertecchia.

primary cause of poor air quality in large cities like Beijing, Mexico City, São Paulo and even Los Angeles. In São Paulo the air quality has improved remarkably as gasoline was replaced by ethanol; today it represents more than 50 percent of the fuel used in cars.

In addition, over its life cycle, ethanol from sugarcane produces considerably lower amounts of CO_2, the main contributor to global climate change, than gasoline. This is because sugarcane bagasse, the fibrous waste that remains after the plant is crushed, can provide the heat and electricity needed in ethanol production, including the crushing and distillation processes.[9]

The calculations mentioned above do not include emissions from changes in land use, including massive deforestation, which could cause increased emissions of greenhouse gases (GHG), as Fargione et al. demonstrated.[10] However, they looked at a worst-case scenario that is not currently occurring, since biofuel production is not expanding into virgin tropical forests. If that did happen, of course, it would release a large amount of CO_2, but extensive studies have been conducted on the CO_2 releases resulting from other agricultural practices that do not involve deforestation, and the results are much less alarming.[11]

The whole issue of CO_2 emissions from changes in land use, as raised by Searchinger et al,[12] is not really a matter of food versus fuel, but should more appropriately be called a problem of food versus climate, since it applies to the expansion of agricultural areas in general. In addition, in Brazil, sugarcane plantations are being expanded into degraded pasturelands and are not displacing other crops. They are also very far from the wet tropical Amazonia forest where sugarcane does not grow well, as Figure 3 shows.

In 2001, in the state of São Paulo, the average number of cattle per hectare was 1.28; as of 2008 it had increased to 1.56, because the expanding sugarcane plantations put pressure on cattle grazing. In the country as a whole the density is even lower, at closer to one animal per hectare.[13] The deforestation in the Amazon basin is linked closely with the raising of cattle for meat, for both domestic consumption and export; it is not linked with ethanol production. Today, Brazil has approximately 200 million head of cattle on 237 million hectares.[14]

The expansion of ethanol production has had important repercussions for the ownership and management of the sector, which in Brazil is entirely in the hands of private groups. Although Petrobras, the state-owned Brazilian oil company, is beginning to invest in this area, it is still a very small player.[15] Traditionally, sugar-producing units were family-owned enterprises such as Costa Pinho, São Martinho, and Santa Elisa, but new ones are owned by Brazilian companies including Votorantim, Vale, and Odebrecht. Foreign companies entering the sugarcane business include French (Tereos, Louis Dreyfus), Spanish (Abengoa), British (British Petroleum), and Japanese (Mitsui, Marubeni) groups. The financial sector is also quite visible, including Merrill Lynch, Soros, and Goldman Sachs. The presence of foreign investors has given the sector a new dynamism and new concepts of management, but as of 2007, investments by foreigners were only 12 percent of the total.[16]

THE SUSTAINABILITY OF ETHANOL PRODUCTION FROM SUGARCANE

One crucial question surrounding the growth of ethanol production from sugarcane in Brazil is the sustainability of that growth. What are the issues regarding soil quality, water consumption, and agrochemical inputs, as well as the social impacts? Goldemberg et al explored these issues exhaustively in a recent article,[17] summarized here.

Soil Quality

Sugarcane culture has become more sustainable over the years as practices have been introduced to protect against erosion, soil compaction, and moisture loss, and to insure the appropriate use of fertilizers. In Brazil, some soils have been producing sugarcane for more than 200 years, with no reduction in yield. Sugarcane culture in Brazil is well known for its relatively small loss of soil to erosion, especially when compared to soybeans and corn.[18]

Definitions of First- and Second-generation Biofuels

First-generation biofuels

First-generation biofuels are those on the market in considerable quantities today. Typical first-generation biofuels are sugarcane ethanol, starch-based or "corn" ethanol, biodiesel, and pure plant oil (PPO). The feedstock for producing first-generation biofuels may be crops that produce sugars, starches, or oils, or animal fats, most of which can also be used as food and feed; food residues can also be used. A first-generation biofuel can be blended with petroleum-based fuels, combusted in existing internal combustion engines, and/or distributed through existing infrastructure, or it can be used in existing alternative vehicle technology like flexible-fuel vehicles (FFVs) or natural gas vehicles. First-generation biofuels are produced commercially today; almost 50 billion liters annually. There are also other niche biofuels, such as biogas, which are derived through the anaerobic treatment of manure and other biomass materials. However, the relatively small volumes of biogas are currently used for transportation.

Second-generation biofuels

Second-generation biofuels are those biofuels produced from cellulose, hemicellulose, or lignin. These biofuels can also be blended with petroleum-based fuels, combusted in existing internal combustion engines, and distributed through existing infrastructure; they may also be dedicated for use in slightly adapted vehicles with internal combustion engines, e.g., vehicles for di-Methyl Ether (DME). Examples of second-generation biofuels are cellulosic ethanol and Fischer-Tropsch fuels; the latter technology synthesizes fuel from gases produced from the gasification of fossil fuels or biomass.

Source: IEA Bioenergy Task 39. http://www.task39.org/About/Definitions/tabid/1761/languange/en_US/Default.aspx.

Water

Water is used in two ways in producing sugarcane and ethanol. First, great quantities of water are needed to grow the cane. The cane requires significant rainfall, in the range of 1,500 to 2,500 mm a year, ideally spread uniformly across the growing cycle.[19] Most sugarcane production in Brazil relies on rain, rather than irrigation, including nearly the entire São Paulo sugarcane-producing region.

Large amounts of water are also used to convert sugarcane to ethanol. In 1997, this amount was calculated as 21 cubic meters per ton of cane. Of that, 87 percent was used in four processes: sugarcane washing and three other industrial processes of ethanol production. However, most of the water used is recycled, and water consumption has decreased substantially in recent years. Also, a dry process for washing cane is replacing the standard wet-washing process.[20] In addition, sugarcane is 70 percent water, which should provide enough for all the steps needed in ethanol production. Distilleries are being developed to be self-sufficient in their water consumption.[21]

Agrochemicals

Many inorganic compounds are introduced during the production of ethanol, including chemicals that kill weeds, insects, mites, and fungi, along with defoliants and other chemicals that help the cane to mature more quickly.

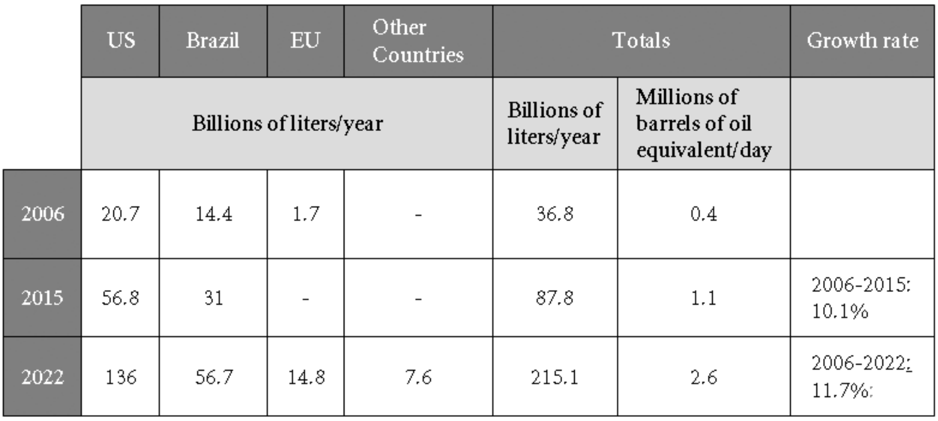
Fewer agrochemicals are used in sugarcane production than for some other crops. Pesticide consumption per hectare for sugarcane is lower than for citrus, corn, coffee, and soybeans. On the other hand, sugarcane requires more herbicides per hectare than coffee, but still less than do citrus, corn, and soybeans. Also, comparing Brazil's major crops (those grown on areas larger than one million hectares), sugarcane uses smaller amounts of fertilizer than cotton, coffee, and oranges, and about the same amount as soybeans. It also uses less fertilizer than sugarcane crops in other countries; for example, Australian cane growers use 48 percent more fertilizer than Brazilians.[22] One practice that helps here is using industrial waste as fertilizer, especially vinasse, the byproduct of ethanol distillation process, and filter cake, which remains after cane juice is filtered and then goes through a process of fermentation/distillation, which results in ethanol. This has led to substantial increases in productivity and in the potassium content of the soil.[23]

Genetic research, especially the selection of resistant varieties, has made it possible to reduce the diseases affecting sugarcane, such as the mosaic virus, sugarcane smut and rust, and the sugarcane yellow leaf virus. With genetic modifications, some now being field tested, plants are more resistant to herbicides, fungus, and the sugarcane beetle. At present, more than 500 commercial varieties of sugarcane are being grown.

Social Aspects

Brazil's labor laws are well known for their worker protection. Workers involved in sugarcane production experience better employee relations, and better protection of their rights, compared to those in other rural sectors. Overall, 40 percent of Brazilians are in formal employment; in comparison, in the sugarcane industry the rate is now 72.9 percent (up from 53.6 percent in 1992); it is 93.8 percent in São Paulo as of 2005 and only 60.8 percent in the north/northeast region.

Many of Brazil's sugarcane plantations are large, and almost 75 percent of the land in use is owned by large producers. However, in the southeast, around 60,000 small producers are organized in cooperatives. A long-established payment system based on the sucrose content in sugarcane has promoted significant growth in agricultural productivity. In the southeast, people working with sugarcane earn



	US	Brazil	EU	Other Countries	Totals		Growth rate
	Billions of liters/year				Billions of liters/year	Millions of barrels of oil equivalent/day	
2006	20.7	14.4	1.7	-	36.8	0.4	
2015	56.8	31	-	-	87.8	1.1	2006-2015: 10.1%
2022	136	56.7	14.8	7.6	215.1	2.6	2006-2022: 11.7%:

Table 1. Ethanol Consumption in Brazil, U.S., EU, other countries.

more than those working with coffee, citrus, and corn, but less than those working with soybeans, as that work is highly mechanized and the jobs more specialized. In the northeast, people working in sugarcane earn more than those in coffee, rice, banana, manioc (cassava) and corn; their income is about equivalent to that for citrus, and lower than for soybeans. However, the enforcement of labor regulations in some parts of the country could be improved.

INTERNATIONAL DIMENSIONS OF THE ETHANOL PROGRAM

The 2007 U.S. Energy Bill[24] set a target of producing 15 billion gallons (56.8 billion liters) of ethanol per year from corn by 2015, using first-generation technologies, which will probably require an agricultural area of approximately 14 million hectares.

Further expansion of production is planned, up to 21 billion gallons (79.5 billion liters) a year, using cellulosic materials and second-generation technologies that are still in an experimental phase. By 2020 the European Union directive will require 3.9 billion gallons per year to replace 10 percent of the gasoline it uses, but today it produces only two billion liters per year, mainly from sugar beets.[25] Production of ethanol from corn, using first-generation technologies, will be at least 87.8 billion liters per year in 2015, up from 36.8 billion in 2006, as shown in Table 1.

There is an important difference between the production of ethanol from sugarcane, or from corn in the U.S., and from starchy feedstocks such as wheat and sugar beets in Europe. The industrial process requires external sources of energy (fuel oil or gas) to supply electricity and heat. In practical terms, in the U.S. and Europe, ethanol is obtained by burning coal (the main source of energy in the region) to turn corn into ethanol; on the other hand, sugarcane converts the sun's energy into ethanol through photosynthesis. The concept of energy balance is used

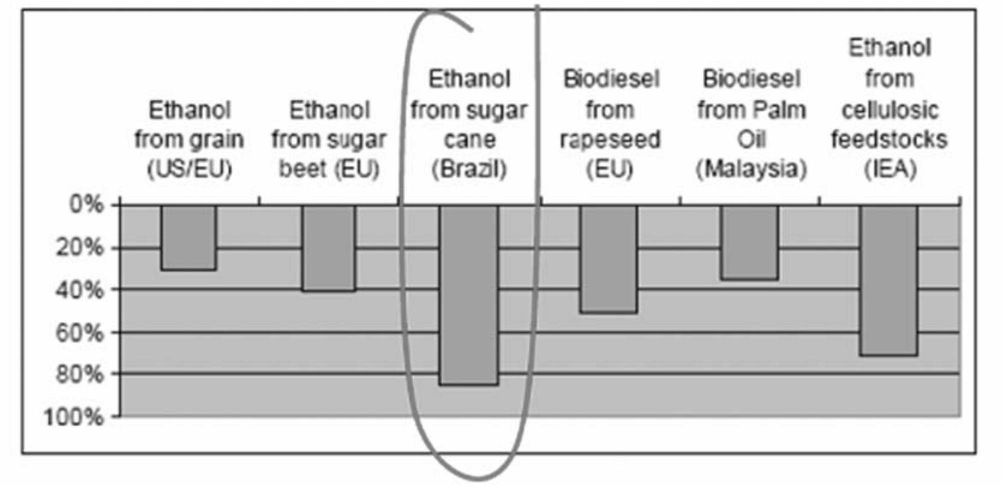


Figure 4. Reductions in GHG Emissions per KM from Biofuels, compared with Gasoline and Mineral Diesel.

Source: R. Doornbosch, and R. Steenblik, 2007. "Biofuels: Is the cure worse than the disease?" Presentation at OECD Roundtable on sustainable development, Paris, September, 2007, (p. 17) www.foeeurope.org/publications/2007/OECD_Biofuels_Cure_Worse_Than_Disease_Sept07.pdf .

to evaluate the use of fossil fuels in preparing ethanol: it is the ratio of the amount of energy contained in the ethanol to the amount of fossil fuel energy used to produce it. For sugarcane this ratio is 8:1, and for corn in the U.S. only it is 1.3:1.

Many studies have been conducted on this subject and the results are sensitive to assumptions about the use of fertilizers, pesticides, and other inputs. Still, a fair estimate is that compared to gasoline, ethanol from corn emits 30 percent less CO_2 and ethanol from sugarcane 82 percent less, as Figure 4 shows.

In the U.S., efforts to expand ethanol production from corn will face severe obstacles. Already 18 percent of the nation's corn, grown on a total of 37 million hectares, is being used for ethanol production, and that land use is cutting into soybean production. Production of ethanol from cellulosic materials, which could be a solution, is still facing technological problems that are not likely to be solved by 2015. However, productivity increases, including genetic modification, might help to significantly reduce the amount of additional land needed.[26]

This large demand for ethanol, and the corresponding use of agricultural land to produce it, has generated a number of objections to the use of biofuels. Some argue that the competition between land for fuel (ethanol) and land for food, in both the U.S. and Europe, is causing famine around the world and leading indirectly to deforestation in the Amazon and other tropical areas.[27] The recent rise in the prices of agricultural products, after several decades of declining real prices, is often seen as a cause of famine, and led to the politically laden controversy of fuel "versus" food. In the aggregate, grain prices have more than doubled since January

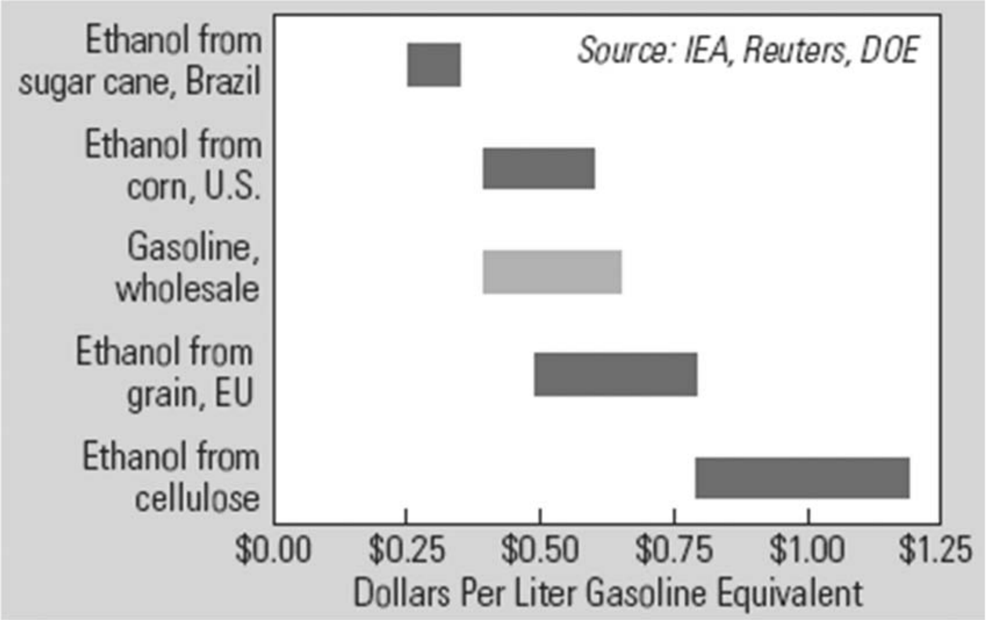


Figure 5. Cost Ranges for Ethanol and Gasoline Production, 2006

Source: World Watch, 2006. Biofuels For Transportation: Global Potential and Implications for Sustainable Agriculture and Energy in the 21st Century (p. 2) www.worldwatch.org/system/files/EBF008_1.pdf.

2006, with over 60 percent of the rise since January 2008, closely following the price of petroleum; prices began to drop as the 2008 crop was harvested. In contrast, the point has been made that higher crop prices will not necessarily harm the poorest people; many of the world's 800 million undernourished people are farmers or farm laborers, who could benefit from higher prices.[28] More recently the price of agricultural products has decreased following the decline in petroleum prices.

To keep the issue in perspective, it is important to remember several facts. First, around the world, 93 million hectares are currently being used to grow soybeans and 148 million hectares for corn, while the amount used in the U.S. to produce ethanol is approximately seven million hectares. Second, in general the prices of food commodities have been decreasing since 1975, but fluctuations frequently occur in those prices, as well as in the areas planted and the prices of crude oil. Those fluctuations, which have occurred for decades, result from an enormous number of factors and events.[29]

Worldwide, 1.5 billion hectares of the arable land is already being used for agriculture and another 440 million hectares is potentially available, including 250 million hectares in Latin America and 180 million in Africa. So the area currently being used for biofuels is only 0.55 percent of the land in use; even if it were to grow by an order of magnitude, it would not be a very disturbing expansion.[30]

	Ethanol			Biodiesel		
	Total, in US$ billions	Billions of liters	US $/liter	Total, in US$ billions	Billions of liters	$/liter
US	5.8	20.7	0.28	0.53	0.96	0.55
EU	1.6	1.6	1.0	3.1	4.43	0.70
Total	7.4	22.3	-	3.63	5.39	-

Table 2. Subsidies for biofuels in the U.S. and EU, 2006

Source: R. Steenblik, 2007. Biofuels – At What Cost? Geneva: The Global Subsidies Initiative (GSI) of the International Institute for Sustainable Development (IISD). www.globalsubsidies.org/files/assets/oecdbiofuels.pdf.

This problem has been extensively analysed in many reports, particularly by the World Bank,[31] which pointed out that several individual factors have driven up grain prices and in combination led to an upward price spiral. Among them are high energy and fertilizer prices, the continuing depreciation of the U.S. dollar, drought in Australia, growing global demand for grains (particularly in China), changes in some nations' import-export policies, speculative activity on future commodities trading, and regional problems driven by subsidies of biofuel production in the U.S. and Europe. For example, in the U.S., from 2006 to 2007, corn acreage grew 19 percent to almost 37 million hectares, an increase of 7 million hectares. Most of this expansion came at the expense of soybean acreage, which decreased by 17%, from 31 to 26 million hectares, 5 million hectares.[32] This is approximately 6 percent of the world's area used for that crop, and that change is helping to drive up prices.

Though these land changes were reversed in 2008, other countries had to expand their soybean production, possibly increasing deforestation in Amazonia. Such speculations about a "domino effect" are not borne out by the facts: the area used for soybeans in Brazil (mainly in Amazonia) has not increased since 2004.[33] The reality is that deforestation in the Amazon has been going on for a long time at a rate of approximately one million hectares per year[34,] and recent increases are due not to soybean expansion but to cattle and are unrelated to ethanol production.

REPLICATING THE BRAZILIAN EXPERIENCE ELSEWHERE

Almost 100 countries are producing sugarcane, over an area of 20 million hectares (approximately 0.5 percent of the total world area used for agriculture). The 15 most important producers represent 86 percent of the total production of sugarcane.[35] It is easy to convert sugar plants to ethanol distilleries and most of the exist-

Biofuels and the World Trade Organization

The World Trade Organization (WTO) does not currently have a specific trade regime for biofuels. Therefore, international trade in biofuels falls under the rules of the General Agreement on Tariffs and Trade (GATT, 1994), which covers trade in all goods, as well as other relevant WTO agreements such as those on agriculture, technical barriers to trade, the application of sanitary and phytosanitary measures, and subsidies and countervailing measures. Agricultural products are subject to GATT and to the general rules of the WTO, insofar as the Agreement on Agriculture (AoA) does not contain derogating provisions.

Key trade-related issues include the classification for tariff purposes of biofuel products as agriculture, industrial or environmental goods; the role of subsidies in increasing production; and the degree of consistency among various domestic measures and WTO standards.

The AoA covers products from Chapters 1 to 24 of the Harmonized System, with the exception of fish and fish products and the addition of many specific products, including hides and skins, silk, wool, cotton, flax, and modified starches. The discipline of the AoA is based on three pillars: market access, domestic subsidies, and export subsidies. One of its main features is that it allows members to pay subsidies in derogation from the Agreement on Subsidies and Countervailing Measures.

The Harmonized System classification affects the way products are characterized under specific WTO agreements. For example, because ethanol is considered an agricultural product, it is subject to Annex 1 of the AoA. Biodiesel, on the other hand, is considered an industrial product and is therefore not subject to the disciplines of the AoA. Paragraph 3 (iii) of the Doha Development Agenda has launched negotiations on "the reduction or, as appropriate, elimination of tariff and non-tariff barriers to environmental goods and services." Some WTO members have suggested that renewable energy products, including ethanol and biodiesel, should be classified as "environmental goods" and therefore subject to negotiations under the "Environmental Goods and Services" cluster.

Sources:

FAO, 2007. *Recent trends in the law and policy of bioenergy production promotion and use,* FAO Legislative Study No. 95. Rome: FAO.

GBEP, 2007. *A review of the current state of bioenergy development in G8 +5 countries.* Rome: GBEP Secretariat, FAO. In FAO, 2008, The State of Food and Agriculture 2008. Biofuels: prospects, risks and opportunities. Rome: FAO.
www.fao.org/docrep/010/a1348e/a1348e00.HTM.

ing plants in Brazil have a dual purpose. This makes it clear that the production of ethanol from sugarcane could be expanded significantly if other countries follow Brazil's example, using a fraction of their sugarcane for ethanol.

The question then arises: why are other sugarcane-producing countries not using some of their raw material to produce ethanol, which they could then export

Country	Capacity (m³ ethanol/day)	Status
Colombia	150 x 5	In operation
Venezuela	700 x 4	In construction
Angola	1,000	Firm proposal
Colombia	1,000	Firm proposal
Bolivia	500	Firm proposal
Paraguay	700	Firm proposal
Colombia	300 x 2	Firm proposal
Colombia	100	Firm proposal
Colombia	150	Firm proposal
Colombia	200	Firm proposal

Table 3. Projects under Development.

Source: J.L. Olivério, vice president of operations, Dedini Organization, personal communication.

to the U.S. and Europe, where production costs are significantly higher, as shown in Figure 5.

The main reason is the high import duties imposed on ethanol imports in the U.S. and Europe to protect local industries which are heavily subsidized. Table 2 gives estimates of the subsidies in the U.S. and European Union which totalled almost $12 billion in 2006.

Removing these subsidies is a topic of discussion in the Doha round of negotiations, but prospects for progress in this area are poor (see Box 2). However, several countries in Central America benefit from their privileged access to the U.S. market. For members of the Caribbean Basin Initiative (CBI), the oldest group, up to 7 percent of the previous year's U.S. ethanol demand is exempt from import tariffs.[36] This agreement has been used mostly to allow these countries to import dehydrated Brazilian ethanol; in the past, European hydrous ethanol was also included. Dehydration plants are located in Costa Rica, the Dominican Republic, Trinidad and Tobago, El Salvador and Jamaica. The U.S. imported 482 million liters from these countries in 2006 and 877 million liters in 2007, considerably less than the 1.3 billion liters that the 7 percent limit represents on ethanol imported from Caribbean countries.

The Central America Free Trade Agreement, or CAFTA, signed in August 2004, immediately eliminated all tariffs and quantitative restrictions on 80 percent of manufactured goods in that market, including ethanol, with the remainder phased out over a few years. Nearly all of the 6 nations in CAFTA have already initiated plans to develop large-scale ethanol production. El Salvador is the most advanced;

it has already drafted legislation to continue developing a local ethanol market and is beginning to invest in ethanol production. An old distillery that can produce 60 million liters a year is being revamped to double its capacity and is already exporting all its production. Similar initiatives are underway in Guatemala and Costa Rica.[37]

Across the Atlantic, two key elements of the E.U.'s General System of Preferences are the Everything but Arms (EBA) initiative and the Special Incentive Arrangement for Sustainable Development and Good Governance (GSP+). EBA provides special treatment for 50 least-developed countries, giving duty-free access to imports of all products except arms and ammunition, without any restrictions on quantity, with the exception of rice and sugar up to October 2009.[38] At present, GSP+ benefits 16 countries, mostly in Latin America and the Caribbean.[39] Any GSP+ beneficiary country must be both "vulnerable," according to a definition established in the regulation, and have ratified and effectively implemented 27 specified international conventions in the fields of human rights, core labor standards, sustainable development, and good governance. This program grants special duty-free access to the E.U. market for denatured or non-denatured alcohol.[40]

To benefit from such advantages, a few countries in Latin America and Africa are starting to divert some of their sugarcane to ethanol production and others, especially Venezuela, are expanding their sugarcane plantations. Table 3 provides a list of projects underway around the world.

This development represents a modernization of the sector which traditionally was in the hands of prosperous family groups that benefited from special relationships with the European Union, as described above, that let them sell sugar at far more than the international price; their price was based on the much higher price of locally-produced sugar from sugar beets or sweet sorghum. This comfortable situation discouraged them from entering into the ethanol business, which required additional investments and know-how.

CONCLUSION

If second-generation technologies do not materialize until 2022, most of the ethanol required in the U.S. will probably have to be imported from countries in the Southern Hemisphere, such as Brazil where the expanses of land and good climate particularly favor its production from sugarcane.

If it were possible, worldwide, to place 10 million hectares into sugarcane cultivation, up from the 2.9 million hectares currently in use in Brazil, it would be possible to produce 70 billion gallons of ethanol; together with the U.S. production from corn, that would more than suffice to meet projected worldwide needs as of 2022. Carbon emissions would be reduced by at least 57 million tons per year.

In all likelihood, ethanol consumption, which represented 0.4 million barrels of oil equivalent per day in 2006 (1.2 percent of all gasoline in use in the world) will grow to 2.6 million barrels of oil equivalent per day in 2022, replacing 10 percent of all gasoline used in the world. Considering that current oil consumption is

85 million barrels a day and that it might grow to 100 million by 2012, ethanol would be contributing the equivalent of almost 3 percent of the world's consumption of oil. That is a significant amount and will help drive down the world price of petroleum.

As discussed above, neither the U.S. nor the European Union will be able to produce all the ethanol it needs; in all likelihood they will have to import it from Brazil and other tropical sugarcane-producing countries. This could be a mutually beneficial solution, reducing the cost of fuel for consumers in the U.S. and Europe and generating hundreds of thousands of jobs in the developing countries.

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38. The EBA beneficiaries are Afghanistan, Angola, Bangladesh, Benin, Bhutan, Burkina Faso, Burundi, Cambodia, Cape Verde, the Central African Republic, Chad, Comoros Islands, Djibouti, Equatorial Guinea, Eritrea, Ethiopia, Gambia, Guinea, Guinea-Bissau, Haiti, Kiribati, Laos, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Myanmar, Nepal, Niger, Rwanda, Samoa, Sao Tome and Principle, Senegal, Sierra Leone, Somalia, Sudan, Tanzania, The Congo, The Maldives, The Solomon Islands, Timor-Leste, Togo, Tuvalu, Uganda, Vanuatu, Yemen, and Zambia.
39. The current beneficiaries are Armenia, Azerbaijan, Bolivia, Colombia, Costa Rica, Ecuador, El Salvador, Georgia, Guatemala, Honduras, Mongolia, Nicaragua, Paraguay, Peru, Sri Lanka and Venezuela. GSP+ status will lapse on December 31, 2011, and the countries must reapply for it.
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