# Brazil and Biofuels for Autos: A Model for Other Nations

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***Abstract*—This paper examines the evolution of government policies in Brazil to encourage the switch from petrol to ethanol, and the response of auto producers. It is shown that the USA and other nations are encouraging the use of ethanol as an energy source, and suggests that the success of Brazil may be repeated in other key auto markets.**

***Index Terms*—Automobiles, Brazil, Corn, Ethanol, Food, U.S.A.**

## I. Introduction

Traditionally the battle for leadership in the auto industry was waged in developed nations. Rapid economic development in emerging markets is changing the competitive landscape of virtually all industries, including autos. Strategically, the BRIC economies (i.e. Brazil, Russia, India and China) will assume critical importance in the auto sector. JD Power Associates forecasts that in 2020 Brazil, Russia, India, China are together expected to sell 57.7 million light vehicles, accounting for 46 percent of the global total. Already some of these markets are not 'emerging' – they have truly 'emerged'. Given their size and growth prospects, these markets will influence auto producers' strategy not just in terms of these markets but on a global basis. Already, luxury producers are developing product features for the global market based upon the preferences of buyers in China.

This paper examines the nature and development of the Brazilian market, showing how auto producers have responded to the local political and economic environment to develop a market dependent upon Flexible Fuel Vehicles (FFVs). It considers too the prospects of ethanol-based fuels in other markets. It will be seen that in all major regional markets, there are countries that are introducing policy initiatives to encourage the emergence of FFVs based upon ethanol.

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## II. Current Situation

During the first half of 2011, oil prices have fluctuated between around $95 to $125 per barrel. This has seen US gas prices rise from a national average of $3.10 in February to $3.75 in April. With such oil prices, U.S. businesses and consumers in particular are modifying their driving habits and practices to reduce fuel consumption. For example, United Parcel Service (UPS) has changed its routing to eliminate or reduce right turns, as these resulted in fuel inefficiencies as vehicles waited for a break in on-coming traffic to complete the maneuver. Consumers are shopping more at convenience stores rather than drive longer distances to larger supermarkets and are turning to Online shopping to avoid costly drives to stores [1}.

At the same time food prices and the price of basic crops such as corn and wheat have reached an all-time high. These price increases have simultaneously been the cause and consequence of regional political instability (i.e. in North Africa and the Middle East).

As oil prices rise, the economic consequences for importing nations are significant, especially those that already have a trade deficit. This increases the incentive to use alternative energy sources generally. The auto industry faces a period of uncertainty in that various alternative energy solutions exist and different manufacturers appear more committed to some than others. In short, this is a period of technological uncertainty in terms of the auto industry's future direction.

Rising gas prices is not the only challenging issue facing the auto industry. Some emerging markets are now 'emerged'. Not only are they among the fastest growing, they are also often the largest. China overtook the USA as the world's largest auto market in 2009. Russia is expected to overtake Germany by 2014 as the largest market in Europe. Brazil in 2010 ranked as the largest market in South America and the world's number six;

As the importance of these markets increases, so too may their impact on the global auto industry. For example Germany's luxury car producers are now developing new products for the global markets that are increasingly driven by the preferences of Chinese

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consumers. In this context, the key driver is consumer behavior.

In the past, auto companies have demonstrated a willingness to absorb 'best practices' irrespective of their origins. For example, US producers have recognized that their European operations have been much more advanced in developing quality and efficient small cars. The willingness to source technology internationally is long and well-established in the auto industry.

Given national priorities in terms of energy security, environmental issues and trade deficit issues, the auto industry has been seeking to address its reliance upon gasoline. Japanese producers have led the way with the introduction of hybrids, and in other countries established companies as well as start-ups are now producing electric vehicles. This may be considered a new technology application. Another option and one that is proven is the use of alternative fuels.

Since the mid-1970s, the government in Brazil has supported the growth of the ethanol fuel industry, and today all the leading auto companies in the market offer an extensive range of Flexible Fuel Vehicles (FFVs). In 2010, FFVs accounted for 86.4 per cent of all light vehicles sold in Brazil [2].

In Brazil ethanol is produced from sugar-cane. In other countries however ethanol is derived from crops such as corn. It is argued by some that using corn for fuel as opposed to animal feeds is causing a scarcity that has inflated corn costs, and in turn contributed to rising food costs (i.e. of meat as animals are fed corn-based feeds). Economics aside, some would suggest that there are ethical considerations in diverting crops from food to fuel.

This paper invites consideration of the extent to which 'the Brazilian model' is transferable to other nations, and what conditions need to prevail locally and globally for ethanol and FFVs to be a success in other national auto markets.

## III. Brazil, Government Policy and Alternative Fuel Automobile Production

Brazil is a large country with vast agricultural resources. In the early 1970s, Brazil was the world's largest producer of sugar cane but capacity was far in excess of demand. At the same time, the country relied heavily on imported oil (i.e. it accounted for 80 per cent of its consumption). This combined with a sharp increase in oil prices in 1973 had a major adverse effect on the Brazilian economy as its auto industry comprised conventional petrol-driven vehicles.

The Government responded by introducing in 1975 the National Alcohol Program. It contained four policies to stimulate ethanol production. It required Petrobras, its major state-owned oil company, to purchase a defined amount of ethanol. It provided $4.9 billion in low-interest loans to stimulate ethanol production. It offered subsidies so that ethanol's pump price was 41 per cent lower than the price of gasoline, required all fuels be blended with a minimum of 22 per cent ethanol (E22).

Ethanol can be produced from a variety of feedstock and may be used as a motor fuel. The most common sources of ethanol are grain and sugar – cane or beets. Brazilian ethanol is produced from sugarcane. There are two types of ethanol: *hydrous* ethanol which contains about 96 per cent ethanol and 4 per cent water; and, *anhydrous* ethanol is 99 per cent pure; it can only be used in fuel blends.

The Brazilian government was mainly concerned with the production of anhydrous ethanol in the initial phase of the NAP, before initiating massive investment in the production of hydrous ethanol in the second phase [2]. Hydrous ethanol can be used as a 100 per cent fuel substitute. The growth in Brazilian ethanol production prior to 1990 was mainly in this type of ethanol. Since then *anhydrous* growth has been stronger, so that Brazilian ethanol fuel production is split evenly between both types.

The Government's commitment to NAP remained consistent even when crude oil prices fell and remained relatively low in the 1980s and 1990s. In 2000, Brazil deregulated the ethanol market and removed its subsidies. The ethanol mandate was maintained. Depending on market conditions, all fuels were required to be blended with 20 to 25 per cent ethanol [2].

## IV. Brazil's Auto Industry and Alternative Fuels

Launched in 1979, the Fiat 147 was the first modern car to run on pure ethanol. Sales of ethanol vehicles peaked in 1985 and by 1988 almost 90 per cent of all new cars manufactured in Brazil were E100 (alcohol only) cars [3]. Such rapid progress resulted in an ethanol shortage and in 1990 only 10 per cent of the new cars were E100. Since 1996 sales of E100 vehicles have been weak and flat.

Three main factors intensified automakers' interest in the development of the flex-fuel technology. First, in 1998 Government introduced a car procurement policy called Green Fleet Law that intended to gradually substitute existing official (i.e. government) vehicles for ethanol ones in the following five years, resulting in the purchase of a large number of ethanol vehicles. Second, in 2000 the Institute of Technological Research (Sao Paulo State) hosted a seminar about flex-fuel technology, gathering major automakers and influential companies in the auto industry. Finally, by 2000 ethanol prices declined making ethanol viable for use as an alternative source of fuel. These factors encouraged component suppliers such as Bosch, Delphi, and Magneti Marelli to resume/accelerate research efforts in flex-fuel technology [4].

In April 2003, Volkswagen (VW) launched the first Brazilian FFV in the local market, the Gol 1.6. Other manufacturers soon introduced their own FFVs (see Table I). These vehicles can run on: 100 per cent

ethanol; 25/75 per cent ethanol/gasoline blend (the 25 per cent minimum ethanol mandate); or, any combination of the two.

By 2010 FFVs accounted for 86.4 per cent of the new cars sold in Brazil [2]. Consumers had 59 models from nine producers to choose from. FFVs have electronic sensors that detect the fuel blend mix and automatically adjust the engine combustion. The growing popularity of FFVs has coincided with the decline in popularity of E100 cars. By the end of 2009 there were 37,973 gas stations operating in Brazil. Practically all the gas stations offer pure ethanol side-by-side with gasoline. Sales of ethanol have surpassed the sales of gasoline since 2008.

By comparison, a 2009 study conducted by the U.S.A's National Renewable Energy Laboratory found that only 1,928 gas stations in U.S. offered Ethanol (E85), a little over one per cent of all gasoline stations. The study also showed that 70 per cent of these stations are located in just 10 states [5].

The transformation of the Brazilian auto industry appears to have relied upon a convergence of factors:

- A large agricultural sector capable of growing a suitable crop for ethanol fuel;
- Strong and consistent government support;
- Economic incentive to reduce oil imports; and
- A substantial auto market whose large size justified the world's leading auto companies developing products customized for that market.

The next stage of this paper addresses the extent to which these conditions exist or might be developed in other markets.

## V. ETHANOL PRODUCTION

Ethanol production offers countries several important benefits. It is environmentally-friendly, reduces dependence upon oil imports, and stimulates economic development in rural areas. As previously mentioned, ethanol fuel can be produced from either grains or sugar. Since the early 1990s, the number of countries producing ethanol has increased. This has resulted in a significant rise in ethanol fuel production worldwide (see Tables II and III). Further increases in ethanol fuel production can be expected as countries such as Australia, China, India and Thailand introduce incentives and indeed mandate to boost ethanol production. In 2010, sugar-based ethanol accounted for about 60 per cent of total world ethanol production.

Table III reveals that the USA is the world's largest producer of ethanol. In the USA, ethanol is produced from grains. Recent entrants of grain-based production include Australia, Canada and China. New entrants are expected from Western Europe and Scandinavia. In Brazil and France (and some African nations) ethanol is produced from sugar. India and several countries in Northern and Eastern Europe have commenced sugar based production.

**The USA:** The Environmental Protection Agency in January 2011 expanded approval of E15 to cover almost two thirds of all light duty vehicles on the road. In his State of the Union address, President Obama called for further investment in biofuels in order to reduce dependency on oil [6].

In the USA, the use of 10 per cent ethanol gasoline is already mandated in some U.S. states (i.e. Florida, Missouri, Minnesota, and Hawaii). In 2007, Portland, Oregon, became the first city to require all gasoline sold within city limits to contain at least 10 per cent ethanol. Most cars in use in the U.S. can run on blends of up to 10 per cent ethanol, and motor vehicle manufacturers already produce vehicles designed to run on much higher ethanol blends.

On March 31 2011, President Obama revealed his *Blueprint for a Secure Energy Future*. His goal is to cut US oil imports from present levels by one third by 2025. Not only did he identify biofuels as part of the solution, in a speech to reveal the document he added:

> *"If anyone doubts the potential of these fuels, consider Brazil. Already, more than half – half – of Brazil's vehicles can run on biofuels. And just last week, our Air Force used an advanced biofuel blend to fly an F-22 Raptor faster than the speed of sound. If an F-22 Raptor can exceed the speed of sound using advanced biofuels, your old beater can do the same. In fact, the Air Force is aiming to get half of its domestic jet fuel from alternative sources by 2016. And I'm directing the Navy and the Departments of Energy and Agriculture to work with the private sector to create advanced biofuels that can power not just fighter jets, but trucks and commercial airliners.*
>
> ***So there's no reason we shouldn't be using these renewable fuels throughout America"*** [6].

The President has mandated government agencies to purchase 100 per cent alternative fuel, hybrid, or electric vehicles by 2015.

**Asia:** China is promoting ethanol-based fuel on a pilot basis in five cities in its central and north-eastern regions, as it seeks to create a new market for its surplus grain and reduce consumption of petroleum. In South-East Asia, Thailand is converting some of the cassava stock hold by the government into fuel ethanol. Cassava-based ethanol production is rising to help manage the agricultural outputs of both cassava and sugar cane. With its abundant biomass resources, it is believed that the ethanol fuel program will stimulate economic development in the rural areas while enhancing the balance sheet of fuel imports.

**Europe:** In Europe, a few countries displayed an interest in biofuels in the 1990s. In its 2000 Green Paper, *Towards a European strategy for the security of energy supply*, the European Commission had proposed a genuine action plan aimed at increasing the share of biofuels to more than 20% of European petrol and diesel consumption by 2020 [7].

The EU as a whole became interested in the in 2001 when it started drafting what would become the *Biofuels*

*Directive*. In 2003, the European Union passed its Directive on the Promotion of the use of biofuels and other renewable fuels for transport, officially 2003/30/EC and popularly better known as the *Biofuels Directive*. The directive stipulates that national measures must be taken by countries across the EU aiming at replacing 5.75 % of all transport fossil fuels with biofuels by 2010.

The main concern at the time was the increased dependence of road transport on imported oil coming from OPEC countries and the security risk attached to it. Biofuels used in low blends appeared the only option allowing for the continued use of existing vehicles. They also offered the advantage of reducing greenhouse gas emissions, thus helping the EU to meet its Kyoto Protocol targets. Favourable policies or fiscal incentives in the different Member States resulted in sharp growth of biofuels auto usage.

EU ethanol production has risen dramatically since 2004. The EU is becoming a net importer of ethanol. France, which enjoys much more productive yields than either Brazil or the USA, and Spain are the leading producers in Europe with similar output levels, followed by Sweden. Virtually all of central and southern Europe is expected to commence sugar-based production.

The consumption of bio-ethanol in Europe is largest in Germany, Sweden, France and Spain. Europe produces equivalent to 90 per cent of its consumption (2006). These countries all import ethanol: Germany produced 70 per cent of its consumption, Spain 60 per cent and Sweden 50 per cent (2006). All gas stations in Sweden are required to offer at least one alternative fuel, and every fifth car in Stockholm now drives at least partially on alternative fuels, mostly ethanol. The number of bio-ethanol stations in Europe is highest in Sweden, with 1,200 stations and a fleet of 116,000 FFVs as of July 2008. In the capital, Stockholm, a fleet of Swedish-made electric hybrid buses was introduced to its public transport system on a trial basis in 2008. These buses use ethanol-powered internal-combustion engines and electric motors.

**Central and South America:** Sugar cane can be grown in all countries of Central America, northern South America and the Caribbean, and many have an established sugar cane industry. Several Caribbean countries (i.e. Costa Rica, El Salvador, Jamaica and Trinidad and Tobago) account for around half of all US ethanol imports. Brazil is by far the main source of US ethanol imports and it is eager to transfer technology to other regional economies.

On March 2009 the Colombian government enacted a mandate to introduce E85 FFVs that applies to all vehicles with engines smaller than 2.0 liters. Beginning in 2012, 60 per cent of such vehicles must have flex-fuel engines capable of running with gasoline or E85, or any blend of both. By 2014 the mandatory quota is 80 per cent, rising to 100 per cent by 2016. All vehicles with engines bigger than 2.0 liters must be E85 capable starting in 2013. The decree also mandates that by 2011 all gasoline stations must provide infrastructure to guarantee availability of E85 throughout the country. The mandatory introduction of E85 flex-fuels has been controversial.

In 2008 the Costa Rican government, based on the National Biofuel Program, established the mandatory use of all gasoline with a blend of around 7.5 per cent ethanol. The plan also calls for an increase in ethanol producing crops and tax breaks for FFVs.

## VI. BIOFUELS, CONSUMERS AND ETHICS

Seventy per cent is the generally accepted tipping point of whether consumers purchase ethanol or gasoline for their flexible fuel vehicles. In other words, if the ethanol price is less than 70 per cent the price of gasoline, they will purchase ethanol. Anything over 70 per cent and consumers will purchase gasoline. The need for the discount is due to ethanol's lower energy level per gallon than gasoline. However, the prices of gasoline and ethanol vary independently of each other. So Brazil's FFV program means that consumers have discretion in the combination of gasoline and ethanol they purchase.

As mentioned previously, ethanol production in the USA is based on corn. Subsidies are available to encourage corn production for ethanol production. Growing demand for ethanol has allegedly contributed to the sharp increase in the price of corn. Some would argue that diverting a food crop for auto fuel raises ethical issues.

Peter Brabeck-Letmathe, the chairman of Nestlé, lashed out at the Obama administration for promoting the use of ethanol made from corn, at the expense of hundreds of millions of people struggling to afford everyday basics made from the crop. He described this as 'immoral' [8].

In its *2011 Annual Outlook* report, the Renewable Fuels Association (RFA) in the USA cites reports by the World Bank and the UK's Department of Environment, Food and Rural Affairs that suggest that biofuels have not had much impact on the rise in food prices [9].

Corn-based ethanol production is much less efficient than sugar-cane based ethanol. The USA lacks the climate to be a sugar-cane producer, and it has been suggested that sugar beets would be a more ethical and productive alternative to corn.

## VII. CONCLUSIONS

This paper has examined the extent to which 'the Brazilian model' of ethanol as a substitute for oil could be followed by other nations. In this brief paper it is evident that the future of biofuels will be determined by a range of factors – economic, ethical, environmental, legal, political, social and technological.

Countries have an economic incentive to reduce dependence upon imported oil that will witness price increases as supplies become more limited. They also wish to stimulate economic development in rural areas and promote the agricultural sector.

Ethically, those in the food industry appear to blame diverting crops towards fuel for inflated food prices which also raises ethical issues. Lobbyists for biofuels – especially in corn-based ethanol countries - reject such charges and indicate that a very small proportion of the crop is diverted to biofuels.

From an environmental perspective, biofuels is regarded as a means of complying with Kyoto and reducing greenhouse gasses.

Legally and politically the situation is presently favorable to biofuels, especially in the USA. In the USA and Europe it is evident that the legal environment serves to provide incentives and specific requirements in terms of biofuel usage.

In terms of the social context, consumers' willingness to use biofuels is dependent upon relative prices, convenience of supply and confidence that biofuels will not damage or reduce the performance of their vehicles.

From a technological perspective, the auto industry faces an uncertain future. Biofuels has the advantage of being a proven technology. However, the auto industry is investing in the development of alternative technologies such as hybrids and electric vehicles.

So what is the future? And who will determine the future – auto producers or national governments? The latter on a global basis appear to be increasingly supportive of biofuels. We have now reached the situation where the President of the USA explicitly acknowledges that Brazil's energy policy towards autos is a model for the USA and others.

REFERENCES


[1] B. Jopson, "High petrol prices fuel jump in US online shopping", *Financial Times*, May 4, 2011

[2] Agagência Nacional do Petróleo, Gás Natural e Biocombustíveis,"O Etanol Combustível", 2011 Available: http://www.anp.gov.br/?pg=40786&m=&t1=&t2=&t3=&t4=&ar=&ps=&cachebust=1297220754484

[3] D. Sandalow, "Ethanol: Lessons from Brazil," The Aspen Institute, 2011. [Online]. Available: http://www.aspeninstitute.org/sites/default/files/content/docs/energy%20and%20environment%20program/EEEethanol7.pdf

[4] W. Junior, "A construção do conhecimento no processo de inovação: o desenvolvimento da tecnologia flex fuel nos sistemistas brasileiros (A Construction of Knowledge in the Process of Innovation: the Development of Flex-Fuel Technology in Brazil)", 2010. Available: http://www.teses.usp.br/teses/disponiveis/12/12139/tde-16122010-183852/en.php

[5] K. Moriarty, C. Johnson, T. Sears, and P. Bergeron, *E85 Dispenser Study*. National Renewable Energy Laboratory of the U.S. Department of Energy, 2009 Available: http://www.afdc.energy.gov/afdc/pdfs/47172.pdf

[6] B. Obama, *Remarks by the President on America's Energy Security*, Georgetown University, Washington, D.C., March 30, 2011. Available: http://www.whitehouse.gov/the-press-office/2011/03/30/remarks-president-americas-energy-security

[7] Commission of the European Community,"Green Paper: towards a European strategy for the security of energy supply", 2000.

[8] S. Foley. "Business Policy is causing starvation, says Nestle boss", *The Independent*, 23 March, 2011.

[9] Renewable Fuels Association, "Building bridges to a more sustainable future: 2011 ethanol industry outlook", 2010.


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Table I: Flexible Fuel Vehicles by Manufacturer and Launch date in Brazil

| Manufacturer | Date of launch of the first flex models | Model |
|---|---|---|
| VW | March 2003 | Golf |
| | September 2003 | Polo |
| | July 2003 | Parati |
| | August 2003 | FOX |
| Fiat | June 2003 | Palio |
| | October 2003 | Palio Weekend |
| General Motors | June 2003 | Corsa |
| Ford | July 2004 | Fiesta sedan |
| Renault | October 2004 | Clio sedan |
| Peugeot | March 2005 | 206 flex |
| Honda | November 2006 | Civic |
| | December 2006 | FIT |
| Toyota | May 07 | Corolla |
| Nissan | March 2009 | Grand Livina |
| | January 2009 | Livina |
| | March 2009 | X-Gear |

*Source: Associação Nacional dos Fabricantes de Veículos Automotores (N.D.)*

Table II: Annual Fuel Ethanol Production by Country (2007–2009): Top 10 countries/regional blocks (Millions of U.S. liquid gallons per year)

| Region | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|
| *USA* | *6,498.60* | *9,000.00* | *10,750.00* | *13,720.99 (for North and Central America)* |
| Brazil | 5,943.87 | 7,053.39 | 7,264.73 | 6,921.54 |
| European Union | 570.30 | 733.60 | 1,039.52 | 1,176.88 |
| *China* | *486.00* | *501.90* | *541.55* | *541.55* |
| Thailand | 79.20 | 89.80 | 435.20 | NA |
| *Canada* | *211.30* | *237.70* | *290.59* | *356.63* |
| India | 52.80 | 66.00 | 91.67 | NA |
| Colombia | 74.90 | 79.30 | 83.21 | NA |
| *Australia* | *26.40* | *26.40* | *56.80* | *66.04* |
| Other | | | 247.27 | NA |
| Total | 14,026.37 | 17,916.48 | 20,221.83 | 22.900.00 |

***italics indicates grain-based ethanol production***

Table III: 2010 World Ethanol Fuel Production

| Region | Volume (millions of gallons | Per cent of total production |
|---|---|---|
| North & Central America | 13,720.99 | 59.6 |
| South America | 7,121.76 | 30.9 |
| Europe | 1,208.58 | 5.3 |
| Asia | 785.91 | 3.4 |
| Australia | 66.04 | 0.3 |
| Oceania | 66.04 | 0.3 |
| Africa | 43.59 | 0.2 |
| Total | 23,012.91 | 100.0 |

*Source: Renewable Fuels Association (2010a, b)*