Developing the EV Market in Brazil[1]

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Abstract

During the last four decades, innovative advances have been introduced in the Brazilian energy and automotive sectors, with good market responses.

One decade after the ethanol program launching in the 70's, as a response to the petrol crisis and the great imported oil country dependence, the ethanol car market share achieved 85%, slumping to less than 1% eleven years after, as oil prices dropped. A new impulse for ethanol came in 2003, when flex-fuel cars (run on any gas and ethanol mix) were successfully launched and reached 85% market share in 2007. On CNG, 240,000 new car conversions are made each year, and the country's CNG fleet has already surpassed 1.5 million vehicles. Two years ago biodiesel started being introduced in the energy matrix.

Brazil has enormous potentials for very efficient and clean vehicles, as 85% of its electric power comes from hydroelectric plants, the ethanol, already available throughout the country, can fuel hybrids, as well as the CNG in the future. Despite of these potentials, the Brazilian EV market is yet incipient.

This paper analyzes the EV use growth possibilities, the barriers that difficult the market development, and the alternatives for promoting the adoption of electric driven vehicles.

Keywords: EV market, ethanol, flex-fuel, CNG, hybrid.

There are innovative and successful experiences of using ethanol and compressed natural gas for fuelling the Brazilian car fleet. What can we learn from those experiences to promote electric vehicles (EV) in Brazil? What would drive the EV usage? What is the EV role before the present bioenergy "fever"?

1. The beginning of the auto industry

In November of 1891, the first motorized car, a Peugeot, arrived in São Paulo. Its owner was the at that time 18-year old Alberto Santos Dumont[2]. In 1919, Ford went to Brazil, and, in 1925, it was GM turn with its Chevrolet brand. The automotive revolution started only in the 50`s, when many auto manufacturers established their vehicle production lines in Brazil (Figure 1), following the federal government restrictions to vehicles and parts import and impulse to definitive auto industry implantation.

[1] Selected for presentation in the **EVS-23 – 23rd International Electric Vehicle Symposium**, December 2-5, 2007, Anaheim, California, USA.

[2] In 1906, Alberto Santos Dumont flied circa of 250 meters in a motorized machine heavier than air before various witnesses and a great multitude in Paris.

In 1953, the state-owned oil company Petrobras (Petróleo Brasileiro S.A.) was created, and the state oil monopoly was established ([1]).

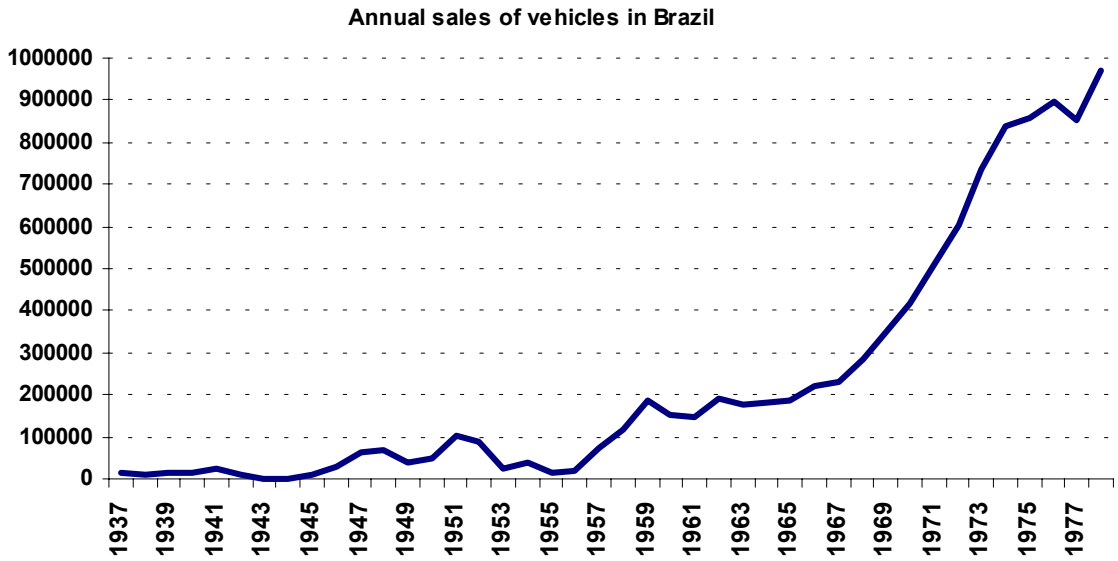


Figure 1: Evolution of vehicle sales in Brazil (1937 – 1978)

2. The Pro-alcohol

The interest in the use of alcohol (ethanol) from sugar cane[3] for fueling vehicles dates from the very beginning of the 20th century. But it effectively started when the 1931 Federal Decree 19717 obliged to mix 5% of alcohol into the imported gas. During the World War II, the mixture increased to 42%, due to the difficulties of gas supplying. Throughout the 50's and 60's, the mixture percentage reduced sensibly, dropping to 2.9% at the beginning of the 70's.

As a response to oil crisis (Figure 2) and the great country dependence of imported oil in the 70's[4], the government increased gas prices and implement restriction for selling gas in Sundays. In 1975, launched the *Pro-alcohol - National Alcohol Program* (Ethanol Program). The Pro-alcohol included the use of ethanol to fuel cars in order to reduce country's imported oil dependence. Federal government decision guaranteed the availability of ethanol in the fuel stations throughout the country, and, to be accepted by

[3] Sugar cane was introduced in Brazil by the Portuguese people in 1532 and since the 17th century the country has been a big sugar exporter.

[4] The oil crisis increased the imported oil expenses from US$ 600 million in 1973 to US$ 2.5 billion in 1974, an enormous impact on the Brazilian Balance of Payments.

the consumer, the alcohol price had to be set lower than gas price (≤65%). A subsidy had to be created. Conversions of gas fueled vehicles to alcohol fueled ones was stimulated.

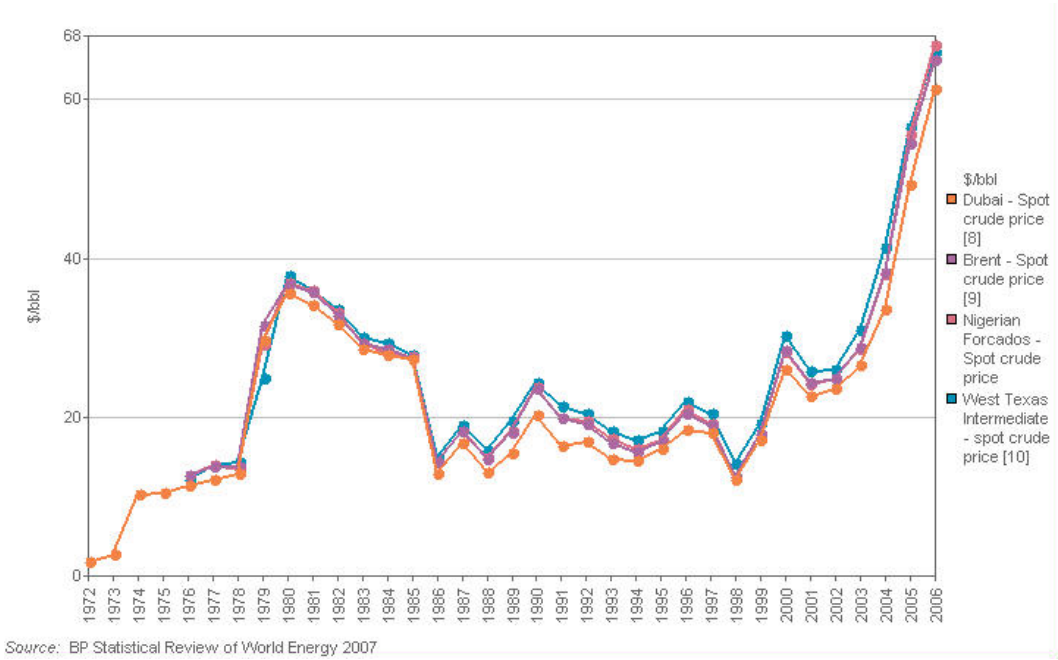
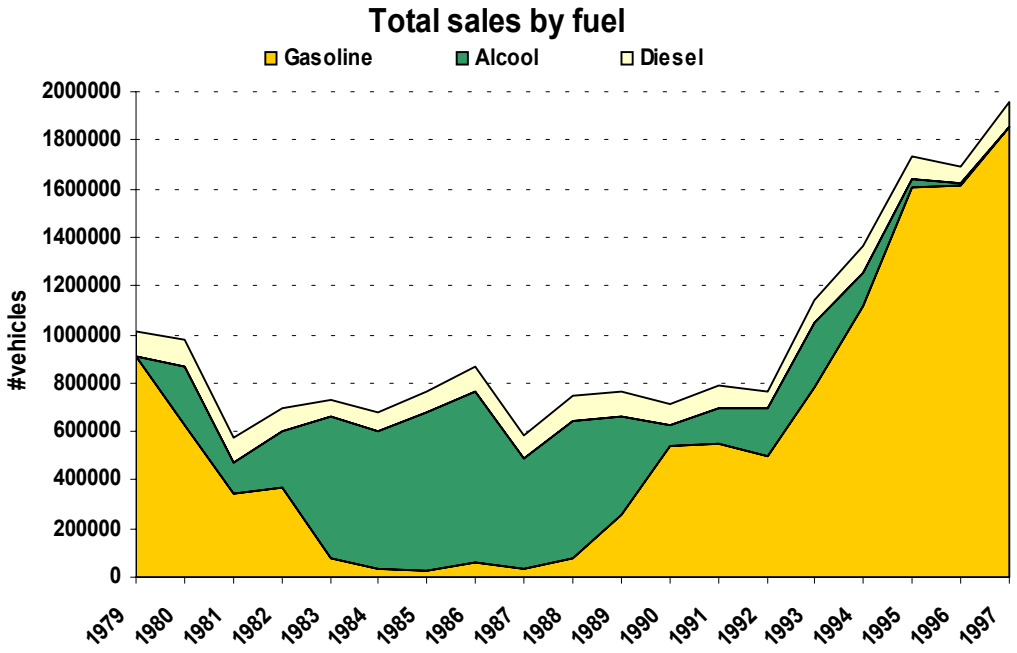


Figure 2: Oil price evolution (1972 – 2006)

After the overcoming the main technical difficulties with metallic materials (corrosion), elastomers (chemical attack) and engine functioning (cold start, compression ratio) with the new fuel by the auto industry, the organization of the ethanol production and distribution, and the approval of the taxes and other incentives for purchasing the new fuel cars, the ethanol vehicle market share reached 85% in 1985. Federal, state and municipal government and state-owned companies fleet managers, following government decision, acquired alcohol vehicles for expanding and renewing their fleets. In the period 1983 – 1988, alcohol vehicles sales represented more than 75% of total vehicles sales and 5.4 million alcohol vehicles were sold from 1979 to 1996. However, as a consequence of the oil prices dropping during the second half of the 80's alcohol vehicle market share slumped to less than 1% in 1996 (Figure 3).

The Pro-alcohol also obliged the increasing the ethanol percentage in the gas, and nowadays all gas sold in the country has mixed 24% of ethanol.

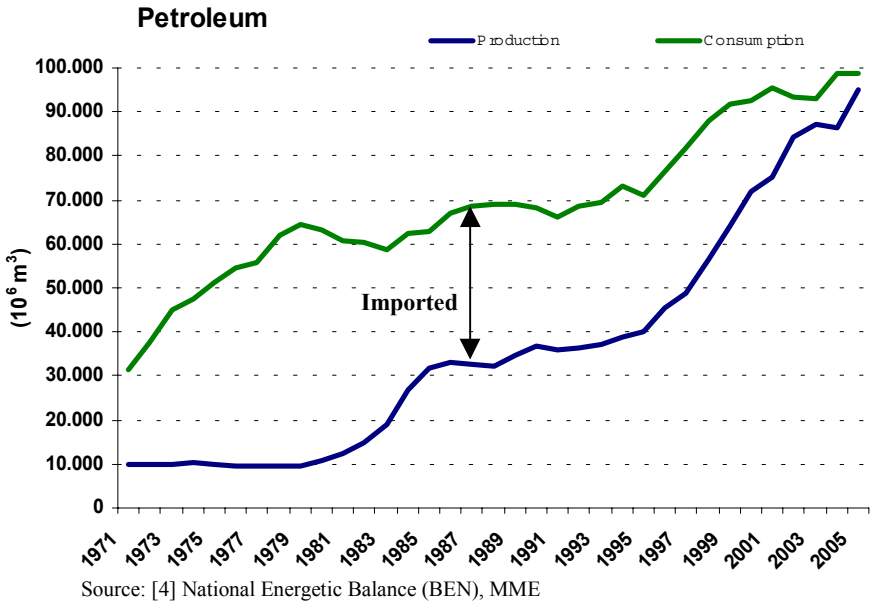


Include cars, light commercials, trucks and buses
Source: [2], [3} Equipe e&e ONG

Figure 3: Vehicle sales by fuel in Brazil (1979 – 1997)

3. The self-sufficiency in oil

By 70's oil crisis, Brazil imported nearly all its crude oil and the economy almost got into state of total collapse. Since then Petrobras has improved investments on oil exploration through innovative techniques and equipment to find in and pump up crude oil from profound sea (2 or more km), as well as, in people training. Today produces more than 1.8 million barrels/day and recently have reached its self-sufficiency in oil (Figure 4).



Source: [4] National Energetic Balance (BEN), MME

Figure 4: Evolution of Brazilian oil demand and production (1971 – 2005)

4. The flex-fuel cars

The bi-fuel (or flex-fuel) technology -- the engine accepts any mix of gas and ethanol -- was introduced in 2003 and 85% of the passenger car and light commercials sold from January to July of 2007 were of this new technology. Although flex-fuel cars are, under some conditions, less efficient (-5% to -2%) than gas or ethanol fueled cars, consumers preferred them. They don't have do decide on their vehicle fuel at the car purchase moment, but at the fuel station and one may find ethanol pumps in almost all fueling stations of the country. The main manufacturers have offered flex-fuel technology in nearly all their models. As can be seen in the Table 1, alcohol and gas vehicles are being substituted for flex-fuel ones.

Table 1: National passenger car and light commercial sales in Brazil (2002 – 2007)

Type of fuel	2002		2003		2004		2005		2006		2007[2]	
	Qty	%	Qty	%	Qty	%	Qty	%	Qty	%	Qty	%
Alcohol	55961	4,5%	36358	3,0%	49329	3,4%	49860	3,1%	1065	0,1%	1556	0,1%
Gasoline	1134523	92,2%	1108543	90,0%	1037987	70,9%	644614	39,9%	333658	18,2%	135796	10,9%
Flex-fuel[1]	0	0,0%	48100	3,9%	330000	22,5%	846710	52,4%	1424112	77,5%	1061286	85,4%
Diesel	39779	3,2%	38054	3,1%	47118	3,2%	74401	4,6%	78636	4,3%	43930	3,5%
Total	**1230263**		**1231055**		**1464434**		**1615585**		**1837471**		**1242568**	

Obs: [1] 2003 and 2004 flex-fuel quantities are estimated. [2] Period: jan-jul/07.

Source: [5] ANFAVEA - Associação Nacional dos Fabricantes de Veículos Automotores

Nowadays 12% of the Brazilian total fleet is flex-fuel and in 2013, this figure will reach 52% ([6]). Ethanol production from sugar cane is very competitive[5] and has grown fast lately (Figure 5).

Flex-fuel technology is being tested in motorcycles. We can forecast a quick market penetration[6], considering the interest in flex-fuel cars showed by the Brazilian consumers.

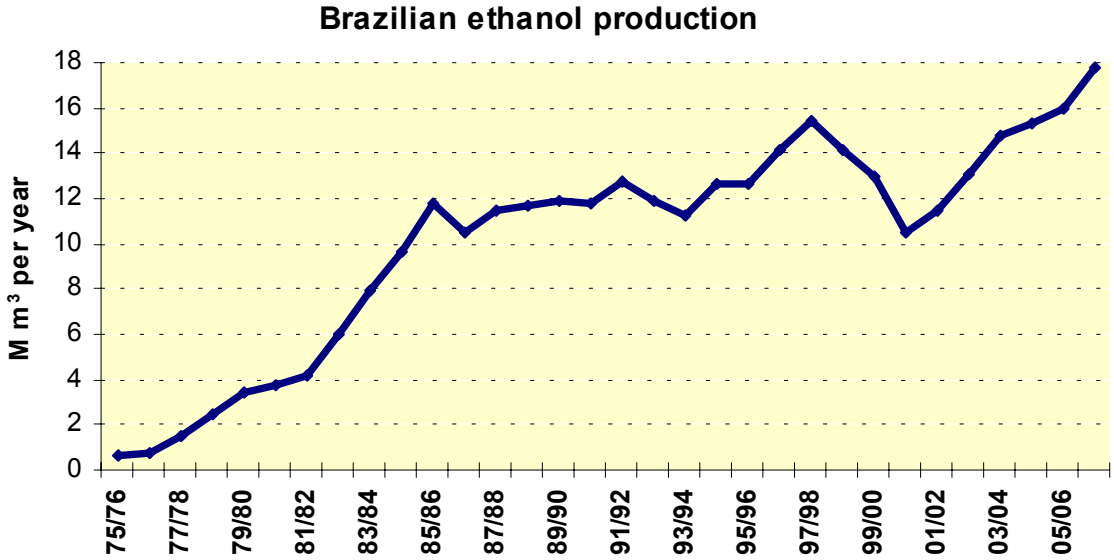


Figure 5: Growth of ethanol production in Brazil (1975 – 2007)

[5] Productivity: 7,000 liters/ha; 8.3 energy units/one fossil energy and US$ 0.3/liter in the production plant.

[6] Motorcycle market has grown fast lately in Brazil: 1.3 million motorcycles were sold in 2006, and an estimated 1.5 million motorcycles will be sold in 2007.

5. The CNG cars

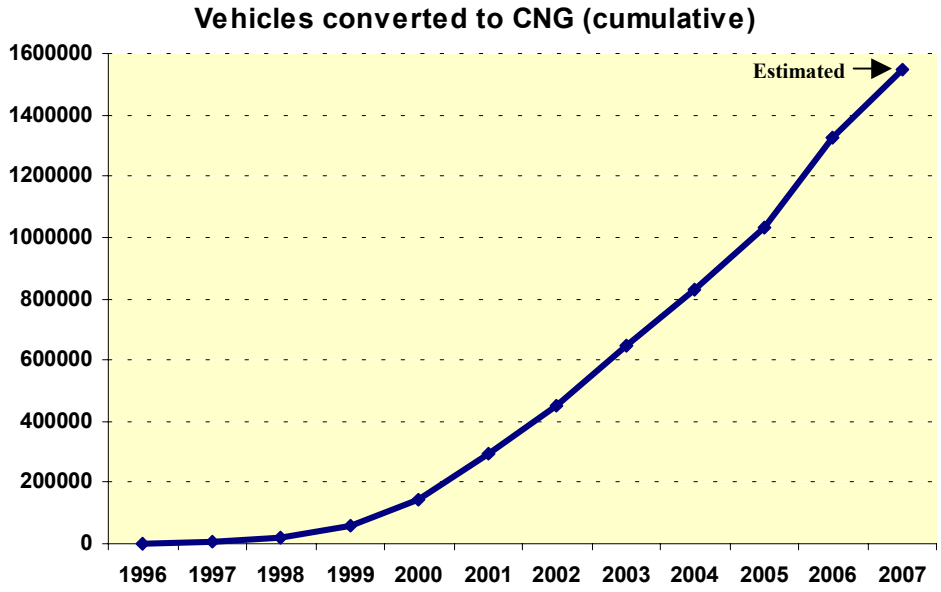
In the beginning of the 90's, the government authorized the use of CNG (compressed natural gas) for fueling taxis and companies fleet vehicles. Due to the low CNG price at pumping station established (see the Table 2), the interest in adapting vehicles increase quickly. But the very limited CNG distribution caused a shortage, inhibiting new cars adaptations.

Table 2: Fuel cost comparison

Fuel	Cost/fuel volume*	Fuel economy	Cost per km
Gas	R$ 2.65/l	10 km/l	R$ 0.265
Ethanol	R$ 1.75/l	8 km/l	R$ 0.219
CNG	R$ 1.22/m^3	13 km/m^3	R$ 0.094

* National average in June, 2007.

From the mid 90's on, a tax exemption was created for CNG taxis, particular vehicles were authorized to be fueled by CNG, CNG distribution was expanded[7], and marketing campaigns emphasized the environmental benefits of natural gas. The quantity of CNG cars start growing fast (Figure 6).



Source: Folha do GNV (vehicular natural gas), Gasnet.com.br

Figure 6: CNG vehicle fleet growth

There are only one CNG car model sold by a manufacturer. The common way to have a CNG car is to "convert" a gas, alcohol or flex-fuel one to run fueled by CNG. The conversion is quite simple[8] and costs

[7] There were 1,516 CNG stations in Brazil in September, 2007. They are distributed along 220 cities of 19 states; 453 were in Rio de Janeiro and 455 in São Paulo. By the end of 2005, according to Petroleum National Agency (ANP), there was 35.6 thousands fuel stations in Brazil.

[8] The GNC cylinder (s), high and low pressure tubes, pressure control device, supply valve, fuel switch, and system condition gauges are installed and no original part is removed from the vehicle. The power of the vehicle reduced by 8% to 12%, when running on CNG. The CNG cylinder occupies 0.2 to 0.4 m^3 of the car trunk.

around US$ 800 to 2,000, depending on the car model and conversion kit quality. The converted car becomes a bi- or tri-fuel vehicle. The payback period for this "investment" is from 5 to 12 months, depending on car usage, and can be shorter in some cases. In Rio de Janeiro, for instance, that conversion cost is quickly compensated by the 75% reduction on the annual tax on motor vehicle ownership fee[9].

Today there are more than 1.5 million vehicles using this alternative fuel in the country. Although the use of natural gas in vehicles is a very inefficient one[10] and introduces additional weight and loss of trunk volume, the conversions to CNG continue growing fast – circa of 240 thousands per year --, as the availability of CNG pumps grows throughout the country, the tax incentives benefit them and the conversion costs drop.

6. The biodiesel

A new government fuel program was recently launched to produce, distribute and use biodiesel mainly in heavy trucks, buses, and light commercials. To promote the use of biodiesel, the federal government established in 2005 the mixture of 2% of biodiesel into diesel (B2) sold around the country from 2008 until 2012, and 5% (B5) after 2012 ([7]). B20 and higher mixtures of biodiesel into diesel are being tested ([8]).

The Brazilian biodiesel program considers technical and economic aspects of production and use of the biosiesel, with focus on social inclusion and regional development via job and income generation. Biodiesel can be produced from various vegetal oils (castor bean, Afro-Brazilian oil-palm, peanut, cotton, coconut, soy, palm, "pinhão manso", sunflower, and others), animal fat, and residual oils and fats. Many incentives (fiscal, financing, and so on) has been created for improving biodiesel production.

7. Electric vehicles for Brazil

During the last four decades, innovative advances were successfully introduced in Brazilian energy and automotive sectors, with good market responses. The increase of the electric vehicles in Brazilian road and non-road fleets is indeed advantageous:

- The electric power in Brazil is environmentally recommended to be used in EVs, as more than 85% of it comes from hydroelectric.
- Ethanol fueled hybrid vehicles are another very interesting option for Brazil, as this renewable fuel is already available throughout the country.
- Could help reducing the imports of some fuels, like natural gas and diesel.
- Would help ensuring Brazilian auto-sufficiency in oil for many additional years, considering the greater efficiency of EVs.
- Could help increasing the exports of various fuels.
- Would improve public health and people life quality, reducing expenses with hospitals, medicines, labor absences, and so on.
- Would improve Brazilian competitiveness.

[9] Annual state tax on motor vehicle ownership (IPVA – Imposto sobre Propriedade de Veículos Automotores).
[10] Only 13 to 15% of the natural gas energy is used for the vehicle traction.

- Would contribute for reducing greenhouse gases.
- Would increase the comfort in the transport.
- Could help attracting investors and promoting the development or introduction of new technology in the country.
- Would create job opportunities for technical and managerial functions.

On the other hand, there are many economic, fiscal, cultural, legal, and regulatory barriers which impede or difficult the growing of the Brazilian EV market:

- Initial acquisition costs of the EVs are high and it is necessary many years to compensate the difference when compared to a gas, alcohol or flex-fuel equivalent car. They can't compete with the "cheap" conversion to CNG. A battery electric car run 5 to 6 km with a kWh, and then would spend R$ 0,010 to R$ 0,0083 /km (considering the residential power price: R$ 0,50/kWh), the same cost level per km of CNG cars (See Table 2).
- People in general do not know electric vehicles (their characteristics, advantages and disadvantages, availability, and so on), nor the majority of government and companies decision makers do.
- Various electric vehicles are already manufactured and/or commercialized today in Brazil: bicycles, small scooters, forklifts, wheelchairs, hybrid electric buses (one of them is an hybrid plug-in), and various types of vehicles for use in restricted areas – not in public roads -- for transportation of people and/or load. Hybrid or battery electric cars for circulating in public roads are not manufactured or sold in Brazil yet. But normally the companies are small and advertise very little their products.
- EVs practically do not exist in the present Brazilian legislation and regulation, making difficulty their commercialization, registering and driving.
- There are very few incentives for buying and using an EV ([9]).
- Emissions limits for vehicles are much less demanding in Brazil than in Europe, US and Japan. It isn't very hard for manufacturers to accomplish them with their conventional vehicles.
- People in general believe that global warming will be solved by substituting oil sub-products for ethanol, biodiesel and natural gas (!!) and that Brazil has all the fuel it needs and doesn't need to reduce consumption.

From Pro-alcohol program, flex-fuel and CNG programs, one could observe that:

- Government decisions are mandatory.
- The involvement of the big auto manufacturers and fuel producers is fundamental.
- Consumers appreciate novelties and accept taking risks.
- Accept to pay a small additional price to have more flexibility and convenience.

- Are very sensitive to fiscal and other incentives.

- Support options that give preference for Brazilian fuels.

EVs are growing in many countries and will grow in Brazil too. The trend is towards the adoption of more efficient and clean vehicles. The question is: How to anticipate and improve short and medium term sales?. How to anticipate the future?

Based on the EV advantages, barriers to overcome and lessons learned from the past experiences, one may recommend the following for promoting the EV use in Brazil:

1. To develop educational programs for key groups, including the press, industry, educational institutions, the responsible for proposition and approval of laws and regulations, opinion makers, and potential users.
2. To advocate fiscal, financing, and other incentives to the development and use of electric driven technology and clean transport.
3. To gather and divulge accurate, updated and complete information on electric vehicle technical, political, educational, and market aspects, promoting its diffusion throughout the media.
4. To develop programs to promote the electric vehicles rapid development, demonstration and commercialization.
5. To promote research and development programs on vehicular electric technology area, standard development inclusive.
6. To advocate the implementation in Brazil of vehicle labeling and, after that, the establishment of limits for fuel economy (like, for instance, minimum of 20 km/l of gas).
7. To engage electric power companies and Petrobras, as well as the big automakers.
8. To stimulate federal, state and municipal governments to include EVs in their government and state-owned fleets.
9. To stimulate state and municipal governments to include hybrid electric buses in their transit fleets.
10. To review legislation and regulations on vehicles and propose the appropriated updating to eliminate the existent barriers to EV use.

Electric driven technology addresses both energy and environment, two crucial and urgent present world worries. It needs to be understood in all its possibilities, advantages and limitations, in order to really provide all its benefits for people and the society.

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