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The introduction of electric vehicles in Brazil: Impacts on oil and electricity consumption

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ABSTRACT

The aim of this article is to measure the impact on energy consumption of the introduction of electric vehicles on to the Brazilian market. To this end, a demand forecast model was used under four different scenarios, each scenario pre-supposing a given level of penetration of the hybrid vehicles in the market. It is shown that with the use of electricity for individual transport, a reduction in the consumption of gasoline, in 2030, of 40.7% would be accompanied by an increase in electricity consumption of 31.3% in relation to official projections, which means a reduction of 28.9% in total energy consumption by the national fleet, or approximately 24.6×10^6 toe/year. Since one of the main obstacles to the introduction of electric cars in Brazil is the competition with the biofuels program, particularly ethanol, we sought to demonstrate here that electricity could act not as a substitute, but rather a complement for ethanol and gasoline. Despite the significant potential domestic production of fossil fuels in Brazil as a result of the discoveries in the pre-salt, the ethanol and the electricity produced in the country come from renewable sources. This circumstance, together with the fact that their domestic production takes place with minimal dependence on foreign raw materials and lesser price oscillation as compared to petroleum derivatives, makes electrical vehicles an attractive alternative.

1. Introduction

Environmental and energy security concerns are causing the United States, China, India and several European countries to turn to electric cars as an alternative to gasoline driven automobiles. For the USA, electric cars represent reduced dependency on imported petroleum and, consequently, greater energy security. They also represent lower greenhouse gas emissions. For the so-called emerging economies, such as India or China, electric cars represent a means of sustaining economic growth, in that they enable the energy demands of the transport sector to be met from a domestic source. These demands are currently relatively low, given the comparatively small size of the fleets of vehicles in such countries, but are expected to grow significantly.

Brazil is an emerging economy whose economic growth has been accompanied by an increasing demand for energy. In 2010, the country consumed 226 million tonnes of oil equivalent (toes), only 3.8% of which came from external sources. 45.4% of the energy consumed comes from renewable sources, which in turn generate 91% of the electricity used [1,2]. Furthermore, 40% of the energy consumed as fuel by light vehicles in Brazil comes from sugar-cane ethanol and 60% from gasoline. The road transport sector is responsible for 26% of the energy consumed internally. Brazil is, today, self-sufficient in terms of petroleum, and official projections indicate that production will outstrip demand by 2030 [3].

There is no public policy in Brazil aimed at fostering the large scale use of electricity by the transport sector. The Brazilian

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vehicle fleet has grown by an average of 7% p.a. since 1970, and is expected to grow at even faster rates over the next few years [4].

The Brazilian fleet of automobiles is currently at an early stage of development and the ratio of automobiles per capita is significantly lower than that observed in developed countries. However, improvement in the economic conditions of the Brazilian population, observed since economic stabilization in the 1990s, has boosted the automobile market in Brazil and led to the increase of the national fleet.

Brazil is the fifth largest producer of automobiles in the world, being responsible for 5% of worldwide production in 2010, or 2,828,273 units [5]. The growth of the national fleet has been accompanied by increased consumption of liquid fuels, given the predominance of internal combustion engine technology in the transport sector.

The electric car has not been given as much attention in Brazil as it has in other countries such as China, India and the US. The large scale use of electric cars with plug-in hybrid electric vehicle (PHEV) technology would enable reduction of the impact on demand for petroleum without compromising the growth of the fleet. It would also increase even further the participation of renewable fuel in the Brazilian transport sector, making the transport cleaner. The sooner the process of introduction of the PHEV onto the rapidly expanding Brazilian automobile market is commenced, the sooner the effect will be felt on the demand for energy.

The aim of this article is to measure the impact on energy consumption of the introduction of electric vehicles on to the Brazilian market applying a demand forecast model. To this end, four different scenarios were envisaged, each scenario pre-supposing a given level of penetration of the hybrid vehicles in the market.

The article is divided into four parts: the first deals with the consumption of energy in Brazil and sets out a brief overview of the car industry and related official policy in the country; the second describes the methodology and premises adopted in the study; the third sets out the principal results obtained on the basis of the model developed and the fourth part sets out the conclusions obtained as a result of the model.

2. Brazil

Brazil is one of the world's top ten consumers of energy. Its consumption grew by an average of 3.3% p.a. between 1970 and 2010, alongside a growth in GDP, in US dollar terms[1], of 4.2% p.a. during the same period. One particularly noteworthy fact is that renewable energy accounts for 45.4% of the Brazilian matrix — the world average being 12.9% [6].

In 2010 the internal offer of energy in Brazil was 270.8×106 toe, 38.3×10^6 toe of which was hydroelectricity and 47.8×10^6 toe was produced from sugar cane derivatives [1]. These figures make Brazil the third major consumer of hydroelectricity in the world, after China and Canada, and make it the world's leading producer of ethanol, responsible for 1/3 of world production [7].

Petroleum accounts for 38.0% of energy consumed internally. As can be seen in Fig. 1, both the production and consumption of energy have intensified their trend of growth since the end of the 1990s.

Brazil is highly dependent on road transport, which, between 1990 and 2000 accounted for over 60% of transported cargo. In comparison, the rate in the United States is 26%, in Australia 24%, and in China 8% [8]. Lack of investment in the upkeep of Brazilian roads, together with the intensity of use, has contributed to their deterioration and consequently to an increase in cargo transportation costs.

In Brazil, heavy goods vehicles consume mainly diesel while light vehicles consume gasoline. Between 1979 and 2009 diesel consumption by the road transport sector grew 662.4%, to reach 34.6×10^3 m^3 (in 2009). This represents an annual growth rate of 5.5%. Gasoline consumption over the same period of time grew by 98.7%, reaching 19.1×10^3 m^3 in 2009, representing average annual growth of 2.1%. In terms of energy, diesel represents 46.8% of the consumption of petroleum derivatives and gasoline represents 18.7% [2].

Ethanol is used as automotive fuel both in its anhydrous and hydrated forms. Anhydrous ethanol is used as octane enhancer for gasoline and is currently blended at the proportion[2] of 20/100. Hydrated ethanol became very popular in the 1980s, but fell into decline in the following decade and only made a comeback in the mid-2000s when *flex-fuel*[3] vehicles became popular. Brazil produced 27.9×10^6 m^3 of ethanol in 2010, of which 1.9×10^6 m^3 was exported [1]. Official forecasts expect ethanol production to reach 66×10^6 m^3 by 2030 [3].

Fig. 2 demonstrates the history of automobile manufacture in Brazil, distinguishing vehicles by the type of technology employed: those powered exclusively by gasoline, those powered by ethanol and those using flex-fuel technology. The dotted line represents the total number of manufactured vehicles.

The beginning, growth and end of the manufacture of ethanol-powered vehicles in Brazil are directly linked to a government program aimed at stimulating the substitution of petroleum derivatives by alcohol produced from sugarcane as automobile fuel. Current government incentives apply equally to flex-fuel vehicles and to vehicles powered solely by ethanol. Given, however, that the overwhelming demand in the market is for flex-fuel vehicles there is virtually no production of cars that run on ethanol alone.

The automobile manufacturing industry commenced in Brazil in the 1950s with the establishment of Ford and General Motors plants limited to the assembly of vehicles from imported kits. There are currently 25 manufacturers in the country and in 2010 Brazil was the world's fifth major automobile producer, responsible for 2,828,273 units — 5% of world production for that year [9]. Up until the 1990s the engineering activities of Brazilian vehicle assembly plants were restricted to adapting imported models to the local climate, road conditions and fuel quality [10]. With the resurgence of investment in the sector in the 1990s, together with increased demand and the removal of

[1] Applying the average 2007 exchange rate.

[2] According to Brazilian law this proportion needs to be maintained at levels between 18% and 25%, and is established by the Federal Government.

[3] *Flex-fuel* technology enables cars to use gasoline and ethanol in any proportion, which means that the motorist can chose the fuel according to price.