

= Flexible @-@ fuel vehicles in Brazil =

The fleet of flexible @-@ fuel vehicles in Brazil is the largest in the world , and since their inception in 2003 , a total of 20 million flex fuel cars and light trucks have been manufactured in the country by June 2013 , and over 3 million flexible @-@ fuel motorcycles by October 2013 . Registrations of flex @-@ fuel autos and light trucks represented 87 @. @ 0 % of all passenger and light duty vehicles sold in 2012 , while flexible @-@ fuel motorcycles represented a 48 @. @ 2 % of the domestic motorcycle production in 2012 . There are over 80 flex car and light truck models available in the market manufactured by 14 major carmakers , and five flex @-@ fuel motorcycles models available as of December 2012 .

Brazilian flexible @-@ fuel vehicles are optimized to run on any mix of E20 @-@ E25 gasoline and up to 100 % hydrous ethanol fuel (E100) . Flex vehicles in Brazil are built @-@ in with a small gasoline reservoir for cold starting the engine when temperatures drop below 15 ° C (59 ° F) . An improved flex motor generation was launched in 2009 which eliminated the need for the secondary gas tank .

According to two separate research studies conducted in 2009 , 65 % of the flex @-@ fuel registered vehicles regularly use ethanol fuel , and use climbs to 93 % of flex car owners in São Paulo , the main ethanol producer state where local taxes are lower , and prices are more competitive than gasoline . However , as a result of higher ethanol prices caused by the Brazilian ethanol industry crisis that began in 2009 , by November 2013 only 23 % flex @-@ fuel car owners were using ethanol regularly , down from 66 % in 2009 .

= = History = =

After the 1973 oil crisis , the Brazilian government made mandatory the use of ethanol blends with gasoline , and neat ethanol @-@ powered cars (E100 only) were launched to the market in 1979 , after testing with several prototypes developed by four carmakers . Brazilian carmakers modified gasoline engines to support ethanol characteristics and changes included compression ratio , amount of fuel injected , replacement of materials that would get corroded by the contact with ethanol , use of colder spark plugs suitable for dissipating heat due to higher flame temperatures , and an auxiliary cold @-@ start system that injects gasoline from a small tank in the engine compartment to help starting when cold .

Flexible @-@ fuel technology started being developed only by the end of the 1990s by Brazilian engineers and in March 2003 Volkswagen do Brasil launched in the market the Gol 1 @. @ 6 Total Flex , the first commercial flexible fuel vehicle capable of running on any blend of gasoline and ethanol .

= = Technology = =

The Brazilian flexible fuel car is built with an ethanol @-@ ready engine and one fuel tank for both fuels . The small gasoline reservoir for starting the engine with pure ethanol in cold weather , used in earlier ethanol @-@ only vehicles , was kept in the first generation of Brazilian flexible @-@ fuel cars , mainly for users of the central and southern regions , where winter temperatures normally drop below 15 ° C (59 ° F) . An improved flex motor generation was launched in 2009 that allowed for the elimination of this secondary gas reservoir tank .

A key innovation in the Brazilian flex technology was avoiding the need for an additional dedicated sensor to monitor the ethanol @-@ gasoline mix , which made the first American M85 flex fuel vehicles too expensive . This was accomplished through the lambda probe , used to measure the quality of combustion in conventional engines , is also required to tell the engine control unit (ECU) which blend of gasoline and alcohol is being burned . This task is accomplished automatically through software developed by Brazilian engineers , called " Software Fuel Sensor " (SFS) , fed with data from the standard sensors already built @-@ in the vehicle . The technology was developed by the Brazilian subsidiary of Bosch in 1994 , but was further improved and commercially

implemented in 2003 by the Italian subsidiary of Magneti Marelli, located in Hortolândia, São Paulo. A similar fuel injection technology was developed by the Brazilian subsidiary of Delphi Automotive Systems, and it is called "Multifuel", based on research conducted at its facility in Piracicaba, São Paulo. This technology allows the controller to regulate the amount of fuel injected and spark time, as fuel flow needs to be decreased and also self-ignition combustion needs to be avoided when gasoline is used because ethanol engines have compression ratio around 12 : 1, too high for gasoline.

Brazilian flex engines are being designed with higher compression ratios, taking advantage of the higher ethanol blends and maximizing the benefits of the higher oxygen content of ethanol, resulting in lower emissions and improving fuel efficiency. The following table shows the evolution and improvement of the different generations of flex engines developed in Brazil.

Brazilian flex cars are capable of running on just hydrated ethanol (E100), or just on a blend of gasoline with 20 to 25 % anhydrous ethanol, or on any arbitrary combination of both fuels. Pure gasoline is no longer sold in the country because these high ethanol blends are mandatory since 1993. Therefore, all Brazilian automakers have optimized flex vehicles to run with gasoline blends from E20 to E25, so these FFVs are unable to run smoothly with pure gasoline with the exception of two models are specifically built with a flex-fuel engine optimized to operate also with pure gasoline (E0), the Renault Clio Hi-Flex and the Fiat Siena Tetraflex.

The flexibility of Brazilian FFVs empowers the consumers to choose the fuel depending on current market prices. As ethanol fuel economy is lower than gasoline because of ethanol's energy content is close to 34 % less per unit volume than gasoline, flex cars running on ethanol get a lower mileage than when running on pure gasoline. However, this effect is partially offset by the usually lower price per liter of ethanol fuel. As a rule of thumb, Brazilian consumers are frequently advised by the media to use more alcohol than gasoline in their mix only when ethanol prices are 30 % lower or more than gasoline, as ethanol price fluctuates heavily depending on the result of seasonal sugar cane harvests.

= = Production and market share = =

After the market launch of the Gol 1.6 Total Flex, the first commercial flexible fuel vehicle capable of running on any blend of gasoline and ethanol, GM do Brasil followed three months later with the Chevrolet Corsa 1.8 Flexpower, using an engine developed by a joint venture with Fiat called PowerTrain. As of July 2013, the following 14 carmakers build and sell flexible fuel vehicles in Brazil: Citroën, Chery, Fiat, Ford, GM do Brasil (Chevrolet), Honda, Hyundai, Kia Motors, Mitsubishi, Nissan, Peugeot, Renault, Toyota and Volkswagen.

Flexible fuel vehicles were 22 % of the new car sales in 2004, 73 % in 2005, 87 % in July 2008, and reached a record 94 % in August 2009. The production of flex-fuel cars and light commercial vehicles since 2003 reached 10 million vehicles in March 2010, and 15 million in January 2012. Registrations of flex-fuel cars and light trucks represented 87 % of all passenger and light duty vehicles sold in the country in 2012. Production passed the 20 million unit mark in June 2013. By the end of 2014, flex-fuel cars represented 54 % of the Brazilian registered stock of light duty vehicles, while gasoline only vehicles represented 34 %. As of June 2015, flex-fuel light duty vehicle sales totaled 25.5 million units.

The rapid success of flex vehicles was made possible by the existence of 33,000 filling stations with at least one ethanol pump available by 2006, a heritage of the early Pró-Álcool ethanol program. These facts, together with the mandatory use of E25 blend of gasoline throughout the country, allowed Brazil in 2008 to achieve more than 50 % of fuel consumption in the gasoline market from sugar cane-based ethanol.

According to two separate research studies conducted in 2009, at the national level 65 % of the flex-fuel registered vehicles regularly used ethanol fuel, and use climbed to 93 % in São Paulo, the main ethanol producer state where local taxes are lower, and E100 prices at the pump are usually more competitive than gasoline. However, as a result of higher ethanol prices caused

by the Brazilian ethanol industry crisis that began in 2009 , combined with government subsidies set to keep gasoline price lower than the international market value , by November 2013 only 23 % flex @-@ fuel car owners were using ethanol regularly , down from 66 % in 2009 .

= = Latest developments = =

= = Flex @-@ fuel motorcycles = = =

The latest innovation within the Brazilian flexible @-@ fuel technology , is the development of flex @-@ fuel motorcycles . In 2007 Magneti Marelli presented the first motorcycle with flex technology , adapted on a Kasinski Seta 125 , and based on the Software Fuel Sensor (SFS) the firm developed for flex @-@ fuel cars in Brazil . Delphi Automotive Systems also presented in 2007 its Multifuel injection technology for motorcycles . Besides the flexibility in the choice of fuels , a main objective of the fuel @-@ flex motorcycles is to reduce CO2 emissions by 20 percent , and savings in fuel consumption in the order of 5 % to 10 % are expected . AME Amazonas Motocicletas announced that sales of its motorcycle AME GA (G stands for gasoline and A for alcohol) were scheduled for 2009 , but the first flex @-@ fuel motorcycle was actually launched by Honda in March 2009 . Produced by its Brazilian subsidiary Moto Honda da Amazônia , the CG 150 Titan Mix is sold for around US \$ 2 @, @ 700 .

Because the CG 150 Titan Mix does not have a secondary gas tank for a cold start like the Brazilian flex cars do , the tank must have at least 20 % of gasoline to avoid start up problems at temperatures below 15 ° C (59 ° F) . The motorcycle ? s panel includes a gauge to warn the driver about the actual ethanol @-@ gasoline mix in the storage tank . In September 2009 , Honda launched a second flexible @-@ fuel motorcycle , the on @-@ off road NXR 150 Bros Mix . During the first eight months after its market launch the CG 150 Titan Mix sold 139 @, @ 059 motorcycles , capturing a 10 @. @ 6 % market share , and ranking second in sales of new motorcycles in the Brazilian market by October 2009 , and by year 's end , both Honda flexible @-@ fuel motorcycles sold a total of 183 @, @ 375 units , representing an 11 @. @ 4 % market share of the Brazilian new motorcycle sales in that year . Cumulative sales of both flex fuel motorcycles reached 515 @, @ 726 units in 2010 , and sales in that year represented 18 @. @ 15 % of all motorcycle produced .

Two other flex @-@ fuel motorcycles manufactured by Honda were launched in October 2010 and January 2011 , the GC 150 FAN and the Honda BIZ 125 Flex . During 2011 a total of 956 @, @ 117 flex @-@ fuel motorcycles were produced , raising its market share to 56 @. @ 7 % . Cumulative production of the four available flex fuel models since 2009 reached 1 @. @ 48 million units in December 2011 . The 2 million mark was reached in August 2012 . Flexible @-@ fuel motorcycle production passed the 3 million @-@ unit milestone in October 2013 , and the 4 million mark in March 2015 .

= = Next generation of flex engines = = =

The Brazilian subsidiaries of Magneti Marelli , Delphi and Bosch have developed and announced the introduction in 2009 of a new flex engine generation that eliminates the need for the secondary gasoline tank by warming the ethanol fuel during starting , and allowing flex vehicles to do a normal cold start at temperatures as low as ? 5 ° C (23 ° F) , the lowest temperature expected anywhere in the Brazilian territory . Another improvement is the reduction of fuel consumption and tailpipe emissions , between 10 % to 15 % as compared to flex motors sold in 2008 . In March 2009 Volkswagen do Brasil launched the Polo E @-@ Flex , the first flex fuel model without an auxiliary tank for cold start . The Flex Start system used by the Polo was developed by Bosch .

= = Direct injection = = =

In 2013 , Ford launched the first flex fuel car with direct injection : the Focus 2 @. @ 0 Duratec

Direct Flex .

= = List of currently produced flexible @-@ fuel vehicles = =

The following is a list of flex @-@ fuel automobiles and light @-@ duty vehicles available in Brazil as of December 2013 .

BMW

BMW 3 Series (F30) ActiveFlex , BMW X1 ActiveFlex .

Chevrolet

Astra , Blazer , Celta , Classic , Corsa , Montana , Meriva , Prisma , S10 , Vectra , Zafira .

Citroën

C3 , C4 , C4 Pallas , Xsara Picasso .

Fiat

Doblò , Linea , Idea , Mille , Palio , Palio Fire , Palio Weekend , Punto , Siena , Stilo , Strada , Uno .

Ford

Courier , EcoSport , Fiesta , Focus , Fusion , Ka , Ford Ranger CD .

Honda

City , Civic , Fit , CR @-@ V , and four motorcycles CG Titan Mix , NXR 150 Bros Mix , GC 150 Fan Flex and the BIZ 125 Flex .

Hyundai

Hyundai HB20

Kia Motors

Kia Soul , Picanto , Soul , Sportage

Mitsubishi

Pajero TR4 , Pajero Sport , Pajero L200 Triton ,

Nissan

Livina , Sentra , Tiida

Peugeot

206 , 307

Renault

Clio , Duster , Fluence , Kangoo , Grand Tour , Mégane , Scénic , Logan , Sandero , Symbol .

Toyota

Toyota Corolla , Etios

Volkswagen

Bora , CrossFox , Fox , Gol , Golf , Kombi , Parati , Polo , Saveiro , SpaceFox , Up , Voyage .