

Bioethanol(EtOH) in Brazil

Brazil EtOH capacity

- [Brazil](#) is the world's second largest producer of [ethanol fuel](#) and the world's largest exporter.
- Brazil and the [United States](#) lead the industrial production of ethanol fuel, accounting together for 89% of the world's production in 2009.
- In 2009 Brazil produced 24.9 billion litres, representing 37.7% of the world's total ethanol used as fuel.

- Brazil is considered to have the world's first [sustainable biofuels](#) economy and the biofuel industry leader, a policy model for other countries.
- Its sugarcane ethanol "*the most successful [alternative fuel to date.](#)*"
- Some authors consider that the successful Brazilian ethanol model is sustainable only in Brazil due to its advanced [agri-industrial](#) technology and its enormous land available
- It is a solution only for countries in the tropical zone of [Latin America](#), the [Caribbean](#), and [Africa](#).

Brazil's competitiveness

- Brazil's fuel program is based on the most efficient agricultural technology for sugarcane cultivation in the world, and cheap [sugar cane](#) as feedstock, the residual cane-waste ([bagasse](#)) is used to process heat and power.
- They results in a very competitive price and also in a high [energy balance](#) (output energy/input energy), which varies from 8.3 to 10.2
- In 2010, the [U.S. EPA](#) designated Brazilian sugarcane ethanol as an [advanced biofuel](#) due to its 61% reduction of [total life cycle greenhouse gas emissions](#).

History

- Since 1976 the government made it mandatory to blend [anhydrous](#) ethanol with gasoline, fluctuating between 10% to 22%.
- In 1993 the mandatory blend was fixed by law at 22% anhydrous ethanol ([E22](#)) by volume in the entire country.
- Since July 1, 2007 the mandatory blend is 25% of anhydrous ethanol and 75% gasoline or [E25 blend](#).

- The Brazilian car manufacturing industry developed flexible-fuel vehicles that can run on any proportion of gasoline (E20-E25 blend) and hydrous ethanol (E100).
- Introduced in the market in 2003, flex vehicles became a commercial success, reaching a record 92.3% share of all new cars and light vehicle sales for 2009.
- In March 2010, the cumulative production of flex-fuel cars and light commercial vehicles reached 10 million vehicles.

Sugarcane plantation

- [Sugarcane](#) has been cultivated in Brazil since 1532 as sugar was one of the first [commodities](#) exported to Europe by the Portuguese settlers.
- The first use of sugarcane ethanol as a fuel in Brazil dates back to the late twenties and early thirties of the twentieth century, with the introduction of the automobile in the country.
- Ethanol fuel production peaked during [World War II](#) and, as German submarine attacks threatened oil supplies, the mandatory blend became as high as 50% in 1943.

Oil crisis

- After the end of the war cheap oil caused gasoline to prevail, and ethanol blends were only used sporadically, mostly to take advantage of sugar surpluses, until the seventies.
- The [first oil crisis](#) resulted in gasoline shortages and awareness of the dangers of oil dependence. As a response to this crisis, the Brazilian government began promoting bioethanol as a fuel.
- The National Alcohol Program, launched in 1975, was a nation-wide program financed by the government to phase out automobile fuels derived from [fossil fuels](#), such as gasoline.

Biofuel for Brazilian cars

- The 1979 Brazilian [Fiat 147](#) was the first modern automobile launched to the market capable of running only on hydrous ethanol fuel ([E100](#)).
- The first phase of the program concentrated on production of anhydrous ethanol for [blending with gasoline](#).
- The Brazilian government made mandatory the blending of ethanol fuel with gasoline, fluctuating from 1976 until 1992 between 10% to 22%.
- Due to this mandatory minimum gasoline blend, pure gasoline ([E0](#)) is no longer sold in the country.

Sugarcane plantation and Typical ethanol distillery and dehydration facility



Research

- A key aspect for the development of the ethanol industry in Brazil was the investment in agricultural [research and development](#) by both the public and private sector.
- The work of [EMBRAPA](#), the state-owned company in charge for applied research on agriculture has allowed Brazil to become a major innovator in [biotechnology](#) and agronomic practices in the world.
- Efforts have been concentrated in increasing the efficiency of inputs and processes to optimize output per hectare of feedstock.
- The result has been a threefold increase of sugarcane yields in 29 years, as the yields went from 2,024 liters per ha in 1975 to 5,917 liters per ha in 2004

Sugarcane biotechnology

- Biotechnology research and genetic improvement have led to the development of strains which are more resistant to disease, bacteria, and pests, and also have the capacity to respond to different environments, thus allowing the expansion of sugarcane cultivation to areas previously considered inaqueate for such cultures.
- By 2008 more than 500 sugarcane varieties are cultivated in Brazil, and 51 of them were released just during the last ten years.
- Since the mid nineties, Brazilian biotechnology laboratories have developed [transgenic](#) varieties, still non commercialized. Identification of 40,000 cane genes was completed in 2003 and there are a couple dozen research groups working on the functional [genome](#), still on the experimental phase, but commercial results are expected within five years.

Research target

- There is ongoing research regarding sugarcane biological [nitrogen](#) fixation, with the most promising plant varieties showing yields three times the national average in soils of very low fertility, thus avoiding nitrogenous fertilization.
- There is also research for the development of second-generation or [cellulosic ethanol](#). In São Paulo state an increase of 12% in sugar cane yield and 6.4% in sugar content is expected over the next decade.
- This advance combined with an expected 6.2% improvement in fermentation efficiency and 2% in sugar extraction, may increase ethanol yields by 29%, raising average ethanol productivity to 9,000 liters/ha.

Biofuel production process

- [Sucrose](#) extracted from sugarcane accounts for little more than 30% of the chemical energy stored in the mature plant; 35% is in the leaves and stem tips, which are left in the fields during harvest, and 35% are in the fibrous material ([bagasse](#)) left over from pressing.
- Most of the [industrial processing](#) of sugarcane in Brazil is done through a very integrated production chain, allowing sugar production, industrial ethanol processing, and electricity generation from byproducts.
- The typical steps for large scale production of sugar and ethanol include [milling](#), [electricity generation](#), [fermentation](#), [distillation](#) of ethanol, and [dehydration](#).

- Once harvested, sugarcane is usually transported to the plant by [semi-trailer trucks](#). After [quality control](#) sugarcane is washed, chopped, and shredded by revolving knives. The feedstock is fed to and extracted by a set of mill combinations to collect a juice, called [garapa](#) in Brazil, that contain 10–15% sucrose, and [bagasse](#), the fiber residue.
- The main objective of the milling process is to extract the largest possible amount of sucrose from the cane, and a secondary but important objective is the production of bagasse with a low moisture content as boiler fuel, as bagasse is burned for electricity generation.

Separation of EtOH

- The cane juice or garapa is then filtered and treated by chemicals and pasteurized. Before evaporation, the juice is filtered once again, producing vinasse, a fluid rich in organic compounds.
- The syrup resulting from evaporation is then precipitated by crystallization producing a mixture of clear crystals surrounded by molasses.
- A centrifuge is used to separate the sugar from molasses, and the crystals are washed by addition of steam, after which the crystals are dried by an airflow. Upon cooling, sugar crystallizes out of the syrup. From this point, the sugar refining process continues to produce different types of sugar, and the molasses continue a separate process to produce ethanol.

- The resulting molasses are treated to become a sterilized molasse free of impurities, ready to be fermented. In the [fermentation](#) process sugars are transformed into ethanol by addition of [yeast](#). Fermentation time varies from four to twelve hours resulting in an alcohol content of 7–10% by total volume ([°GL](#)), called fermented wine. The yeast is recovered from this wine through a centrifuge.
- Making use of the different boiling points the alcohol in the fermented wine is separated from the main resting solid components. The remaining product is hydrated ethanol with a concentration of 96°GL, the highest concentration of ethanol that can be achieved via [azeotropicdistillation](#), and by national specification can contain up to 4.9% of water by volume.

EtOH for flex cars

- This hydrous ethanol is the fuel used by ethanol-only and [flex](#) vehicles in the country. Further dehydration is normally done by addition of chemicals, up to the specified 99.7°GL in order to produce anhydrous ethanol, which is used for blending with pure gasoline to obtain the country's [E25](#) mandatory blend.

- The additional processing required to convert hydrated into anhydrous ethanol increases the cost of the fuel, as in 2007 the average producer price difference between the two was around 14% for São Paulo State.
- This production price difference, though small, contributes to the competitiveness of the hydrated ethanol ([E100](#)) used in Brazil, not only with regard to local gasoline prices but also as compared to other countries such as the [US](#) and [Sweden](#), that only use anhydrous ethanol for their flex fuel fleet.