FUEL

# Not even the bagasse is left over


EDUARDO CESAR

## New process could increase alcohol production by 30% and contribute to bringing back the Pro-Alcohol program

YURI VASCONCELOS

A small revolution might occur in the sugarcane and alcohol mills of the country. If they incorporate a new technique developed at the Technology Center (CTC) of the Sugarcane, Sugar and Alcohol Cooperative of the State of São Paulo (Copersucar), in the town of Piracicaba, they will be able to increase the production of alcohol by around 30% without the necessity of planting a single stalk of sugarcane more. What seems to be magic is in truth the result of the total use of the biomass of the sugarcane, more precisely the bagasse. It is estimated that 300 million tons of sugarcane per year in the country are milled, resulting in 81 million tons of bagasse. Of this total, close to 70 million tons are burned in furnaces for the production of electrical energy to feed the mills themselves. With the use of 50% of the sugarcane straw, currently burned or left in the field, 35 million tons of bagasse could be reused for the production of alcohol. Added on to the 11 million that are already in excess, it will be possible to produce 5.4 billion liters of alcohol per year, which accounts for about 30% of the current production. The production of electrical energy would not be damaged assuming that the major part of the furnaces in existence are substituted by others, more modern and efficient, which make better use of burning the bagasse and the straw.

The new technology is a result of two decades of studies, in a piece of research that brought together researchers from Copersucar and the Dedini Group, one of the major equipment manufacturers for the sugar-alcohol industry. They managed to prove that it is possible to make carburant ethyl alcohol (ethanol) from the bagasse of sugarcane, through a process baptized as Dedini Rapid Hydrolysis (DHR in the Portuguese acronym). This process has already proved to efficient in laboratory tests and in a prototype on a pilot scale at the CTC and is ready to be tested on the industrial scale. If everything goes well, the new technology will be available for the Brazilian mills beginning in the second half of 2003.

"We're confident that this new technology, up until this point unprecedented in industrial terms, will be very positive for the country", says the chemical engineer Carlos Eduardo Vaz Rossell, the coordinator of Copersucar's project. "All of the developed countries are after this technology, in order to transform vegetal biomass into fuel." For him, the DHR process could supply alcohol at a competitive price; making use of already existing raw materials and freeing up more sugar stalk for the production of sugar. "The technology will make possible the utilization of bagasse to the maximum synergy with current conditions: the same production location, the same product and the same businessmen investing", says Vaz Rossell.

The innovation came about at a moment when the Federal government, mills and car manufacturers are again trying, after many attempts throughout the last decade, to agree among themselves how to put together the re-birth

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Greater production and supply for alcohol could bring back consumer confidence

of the National Alcohol Program (Pro-Alcohol). Created in 1975, to substitute, at low prices, gasoline which was strongly hit by the oil crisis during 1973, the Pro-Alcohol program reached its peak of success between 1984 e 1986, when the percentage of cars coming from the vehicle manufacturers with an alcohol motor reached 96%.

The program began to fail at the end of the 80s when the international price of a barrel of crude oil began to fall and the advantageous relationship of the price between alcohol and gasoline, of up to 40%, went down by half. At the same time, the mills reduced their production of alcohol and increased sugar production, whose international price had become more attractive. The result everyone knows: Long lines to fill up the tank, the loss of confidence by the fuel's consumer and the consequent deceleration of the Pro-Alcohol program. Today only 1% of new cars come off the factory production line to use this fuel.

Another factor that harmed the Pro-Alcohol program was the excessive subsidies given to the mills. The government purchased alcohol at a price much higher than that sold at the gas stations, thus keeping a differentiated price in relation to gasoline. At the beginning of the 90s, the government incentives for the sugar/alcohol sector had consumed close to US$ 11 billion, according to numbers put out in reports by the magazines *Carta Capital* and *Isto É Dinheiro*, in editions of the month of May of this year.

"The maintaining of the price policy, anchored in subsidies, lasted a long time and was one of the limiting factors of the program", asserts the economist Luiz Gonzaga de Mello Belluzzo, a professor at the Economy Institute of the State University of Campinas (Unicamp), former secretary for economic issues at the Finance Ministry and a former State Secretary for Science and Technology in the 80s. "Pro-Alcohol was good, but the subsidies given at the beginning should have been reduced with time to allow the program to become competitive. They were very onerous for the government", explains Belluzzo, who has a favorable view of the revitalization of the program. "The Pro-Alcohol program brings security to the country in the eventuality of the occurrence of problems in the overseas oil market."

The Federal government has already given the green light for a new era of alcohol as a fuel, assuming that the fiscal incentives, common during the start of the program, are forgotten about. The Minister of Development, Industry and Foreign Commerce, Sérgio Amaral, in a note to the press after a meeting with mill owners in May, stated that the Pro-Alcohol program will depend on the market and on the guarantee, from the mills to the consumers, that there will be no shortage of alcohol. "What is needed is that the government, mills and the car manufacturers get together to establish goals and conditions that give sustainability to the project, mainly on the supply side. Those who do not comply with their part should be punished", suggests the economist Luciano Coutinho, a professor at the Economics Institute of Unicamp and the first general secretary of the Ministry of Science and Technology when the program was created in 1985. "Things can't be as they were in the past, an irresponsible policy", which was accompanied by a crazy expansion of the fleet without any planning of demand and supply", completes Coutinho. For him, if the errors in the past are corrected, there will be no problem in revitalizing the program. The economist suggests, in order to stimulate the use of the fuel, that part of the fleet be already equipped with flexible alcohol-gasoline motors (*see box below*) and that service vehicles and vans for public transportation make use of alcohol or natural gas.

For the mill owners, a higher supply in the number of alcohol cars is an essential factor in revitalizing the program. "Excess of production of ethanol, we currently have. We need to return to the production of alcohol cars in order to make use of the fuel for the internal market", explains Eduardo Carvalho, president of the Union of the Sugarcane Industry of São Paulo. "The moment is ideal to revitalize the program."

The Federal government also has ambitious plans for exporting the product to the rest of the world. According to studies carried out by Copersucar, the demand for alcohol on the world market is high and tends to grow even more, spurred by the problems related to the oil supply and pollution in large metropolises – as it is known, alcohol is a fuel with enormous environmental advantages when compared with gasoline.

In Europe, it is estimated that the consumption could get as high as 4.5 billion liters by the year 2005. In the United States, the demand will reach 11.9 billion liters in the next two years – today, the American production of etha-

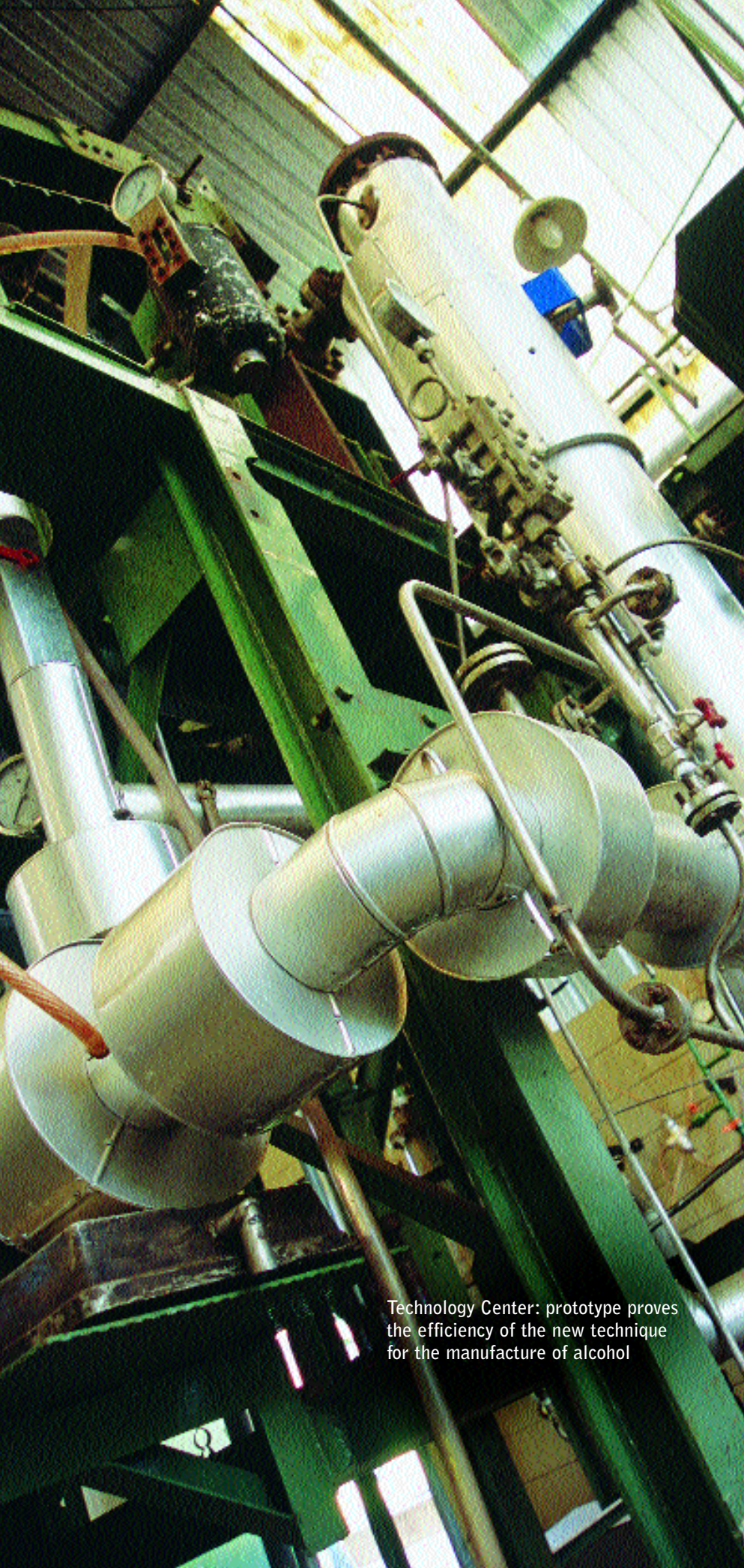
## Gasoline or alcohol? Both

Vehicles with flexible motors or flex-fuel could be an important ally for the reactivation of the Pro-Alcohol program. With it, it is possible to fill up the car with alcohol and gasoline simultaneously, mixing in any proportion or even using the pure fuel. Contrary to the outdated systems that operate with sensors installed in the motor's fuel line, before combustion, it uses a post-combustion sensor, which evaluates the level of oxygen resulting from the burning and re-aligns the module of the electronic injection with information about the fuel available in the tank. The biggest advantage for the consumer is that it could use the lower price of alcohol with the guarantee that one could also fill up the tank with gasoline, in the case of the shortage of the former.

With an eye on this promising niche in the market, Ford has come out in front, in May last, with a prototype of a Fiesta car with a flexible motor gasoline-alcohol, developed by Visteon, a Ford company with its headquarters in the United States. Four prototypes are currently being tested on the roads. However, the management of the factory have already warned: they will only produce the car on an industrial scale if the new Pro-Alcohol program takes off. GM is also developing a flexible model of the Vectra.

In spite of occupying space in the newspaper headlines now, the technology of flexible motors is not something new. In 1992, engineers at Bosch's car parts company, with its headquarters in Campinas, began studies into the manufacture of a flexible motor, and two years later showed the prototype of a GM Omega car. The Magnetti Marelli, a company within the Fiat group that makes fuel injection systems, has also mastered the technology. "Bosch has already invested close to R$ 2 million in the development of this new motor", says Besaliel Botelho, the company's injection systems director. In the forecasts done by the company, the flexible motor will not come into the market from one moment to the next, but only one or two years after the approval of the technology by the government. It will be necessary, explain the engineers of the German company, to have a series of modifications in the industrial process, such as the protection of components of the motor against corrosion caused by the alcohol. According to Bosch, as well as the flexibility at the moment of re-fueling, this new line of motors has another benefit: the reduced emissions of pollutants.

"Alcohol is an extremely beneficial fuel from the point of view of the environment", says the ex-director of Cetesb, Laura Tetti, currently the coordinator at the Chamber of Climatic Changes of the Brazilian Entrepreneurial Center for Sustainable Development. "We're dealing with renewable energy and a lot less pollution than with gasoline. The pollution generated by alcohol, in the emissions that come out of the exhaust pipe of cars, is smaller and less reactive", she assures. The alcohol cars emit 50% less carbon monoxide (CO). In this manner, alcohol does not contribute to a worsening of the greenhouse effect, the gradual warming of the Earth brought on by the burning of fossil fuels.



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Technology Center: prototype proves the efficiency of the new technique for the manufacture of alcohol

nol, extracted from corn, is around 5 billion liters. There, the growing consumption is due to the use of alcohol as a gasoline additive and for its use in cars with alcohol-gasoline flexible motors.

The strategy of the government to export alcohol is also backed by the two economists, though they believe that it will not be easy. "I don't believe that today the United States will buy our alcohol", says Coutinho. "It's practically impossible to sell to the Americans, since the country has strong tariff barriers to protect their own alcohol, which is produced from cereals", complements Belluzzo. "The alternative would be to export the fuel to Europe, China and India", says the economist.

**Support from FAPESP -** The growth of the world market is seen with enthusiasm by the government and the industry managers. Besides being the largest sugar producer in the world, with 33% of the market, Brazil masters like nobody else the technology for the production of sugarcane alcohol. Of the 15.4 billion liters of alcohol produced in the country per year, 9.7 billion are hydrated alcohol and 5.7 billion are anhydrous alcohol, which gets mixed with gasoline, today to a level of 24%. São Paulo state, with 57% of the manufactured volume, is the largest production center and Copersucar, with its 35 affiliated mills corresponds to 22% of national production.

With a favorable scenario for the return in Brazil to the use of alcohol as a fuel, the new technology created by Dedini and Copersucar has all the right ingredients for success. At the beginning of this year, they obtained the financial support of FAPESP to implant a developing processing unit (DPU), which will function at an annex of the São Luiz Mill, in the town of Pirassununga, which belongs to the Dedini company. It is there that the new technology named DHR is being tested on an industrial scale. The total value of the project, which makes up part of the program Partnership for Technological Innovation (PITE), has reached R$ 3.58 million, of which FAPESP has come up with R$ 1.76 million; the Dedini company with R$ 1.32 million; and Copersucar with some R$ 500,000.

The development of the process demanded a huge effort on the part of the researchers. The Dedini company

began to study the hydrolysis (chemical reaction involving water) of the sugarcane bagasse in the early 80s and developed the DHR process in 1993. But only in 1997, when an agreement of technical cooperation with Copersucar was signed, who had already been following several studies related to new uses of the bagasse, did the company reach promising results. From that moment on, a pilot unit at Dedini, with the capacity for processing 20 kilograms of bagasse per hour, was transferred to the CTC, in Piracicaba. "The results verified through this experimental plant were very important", tells the researcher Vaz Rossell, who is also the coordinator of the PITE project. "Now with the mounting of the semi-industrial unit, financed through resources from FAPESP, we can carry out a technical and economic evaluation of the process."

**Organic solvents -** The new UDP will increase the production to 5,000 liters of alcohol per day, produced in a continuous process, which is equivalent to around 50 tons of bagasse. This is still small when compared with a final industrial unit that will manufacture 100,000 liters per day, but it will be essential to evaluate the behavior of the materials and of the equipment during processing under real operational conditions "The UDP is fundamental for demonstrating the reliability of the process and its economic viability", says Vaz Rossell.

The demonstration unit is relatively simple. Formed by a reactor, which operates under pressure of between 25 to 27 kg/cm$^2$ and a temperature of around 190° C, it is continuously fed with bagasse and with an organic hydro-solvent (ethanol, preferentially, though other solvents such as acetone, acetic acid or methanol can be employed) mixed with sulfuric acid. It is this mixture that is going to make the transformation of the cellulose present in the bagasse into glucose. In the next stage, the syrup containing the glucose is purified, to remove undesirable substances, mainly sulfuric acid, and it then receives the addition of nutrients, resulting in a must able to be fermented that will be mixed with the juice and molasses normally used for the manufacture of alcohol. The remainder of the process – fermentation and distillation – is carried out in the installations already in existence in the mill itself.

"The big advantage of the DHR process is its speed", says the chemical engineer Antônio Hilst, a consultant with Dedini, who invented the technique ."The transformation happens in only ten minutes, while the classical processes of hydrolysis, making use of dilute or concentrated acid, take at least five hours." In order to understand how the magic of the transformation occurs, one needs to know beforehand that the bagasse of the sugarcane is a vegetal biomass basically made up of three substances: cellulose, hemicellulose and lignin, present in a proportion of approximately 50%, 30% and 20% respectively. The fracturing of the cellulose for the production of sugar is very difficult because of the presence of lignin, which functions like a protective coating, compacting and uniting the other vegetal polymers. Thanks to it, the fiber of the sugarcane is very resistant in its mechanical and chemical aspects.

In the DHR process, the bagasse remains in the reactor the time necessary for the dissolving of the lignin and the hydrolysis of the cellulose to occur. "At the end of the process, we intend to reach an efficiency of around 60% of the sugar contained in the bagasse", explains engineer Hilst. This is the same as saying that 60% of the cellulose present in the bagasse should become glucose. "With this level of sugar, we have the conditions to guarantee fermentation and distillation that are completely viable from the economic point of view", explains the Dedini researcher.

The glucose is only one of the products resulting from the benefit. Besides it, other by-products are extracted from the bagasse such as methanol, acetic acid, lignin and furfural, whose commercial use could increase even more the income from the process. "For example, lignin could be used as a pre-polymer in resins and in the manufacture of wood agglomerates (with adhesives) or used as a fuel, thanks to its high calorific value", suggests Vaz Rossell. Furfural, which is available on a large scale (15 kilograms per ton of bagasse) could be used in the manufacture of nylon. Everything will depend on market interest.

**Intellectual property -** The researchers evaluate that, in order to make this new technology viable, the mills will have to invest in new industrial DHR modules at approximately R$ 0.90 per liter per year of installed capacity. A unit with production estimated at 100,000 liters per year will cost around R$ 9 million. By the calculations of Copersucar and Dedini, the investment of the utilization of all of the bagasse that will be available when the technology is introduced onto the market will be around R$ 4.9 billion. The estimate is that least 5,000 direct jobs with the new technology will be created.

The Dedini company has already registered various requests for patents referring to the DHR process in Brazil, two of them already having been granted and others currently under analysis. Abroad, patents were requested in some European countries and in Japan, the fact being that the main patent has already been conceded to in the United States. "The industrial property belongs to the three partners and the division of any profits will be shared in the proportion of the participation of each one in the process", explains Vaz Rossell. "The Dedini company will receive close to 60% of the gross income from the sale of licenses for the process, whilst Copersucar will remain with 30% and FAPESP with 10%", he concludes. Consequently, yet another successful technology developed partnership has been completed. Now it is hoped that the DHR can be a new and important ingredient for the return of the Pro-Alcohol program. •

**THE PROJECT**

*DHR Process (Dedini Rapid Hydrolysis) – Projection, Implementation, and Operation of a Unit for the Development of the Process*

**MODALITY**
Technological Innovation Partnership (PITE)

**COORDINATOR**
Carlos Eduardo Vaz Rossell – Copersucar

**INVESTMENT**
R$ 1,822,100.00 (Codistil-Dedini) and R$ 1,751,487.00