BIOCOMBUSTIBILI DURABILI PENTRU ZONELE RURALE ÎN CURS DE DEZVOLTARE: CAZUL BRAZILIEI

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SUSTAINABLE BIOFUELS FOR RURAL AREAS OF DEVELOPING COUNTRIES: BRASILIAN CASE STUDY

The objective of the application is to describe a project for sustainable development, proposed in Brazil regarding energy production and economic self-sufficiency, using as a raw material, the residual oil and other biomass available in this country. Additionally, the potential of biofuel in Brasil is also discussed.

Keywords: Biomass, biofuels, energy, renewable energies, sustainable development
Cuvinte cheie: biomasa, biocombustibili, energie, energie regenerabilă, dezvoltare durabilă

1. Introduction

Since the early '70s, Brazil has started a vast program for the ethanol production from sugarcane, primarily for motor vehicles [1, 2]. Today the ethanol and gasoline consumption are the same, and all the fuelling stations are equipped with alcohol pumps able to supply the so-called "flex" engines (engines fuelled with either gasoline, ethanol or mixtures of them) cars. In Brazil, the energy policy has also aimed at the biodiesel [3]. Since January 1st, 2010, the diesel oil sold throughout Brazil contains 5 % of biodiesel. This rule has been established by

Resolution No. 6/2009 of the National Energy Policy (herewith), which rose 4 % to 5 % the percentage of mandatory blending of biodiesel with diesel. The continued rise in the percentage of biodiesel added to diesel demonstrates the success of the National Program for Production and Use of Biodiesel and experience accumulated by Brazil in the production and large scale use of biofuels. Brazil is among the largest producers and consumers of biodiesel in the World with an installed capacity in January 2010 to around 4.7 billion litters [4].

Actually it is under development a specific "Biodiesel program" based on vegetable oils derived from palm and castor seeds, Jathropha curcas as well as on the waste frying oil recovery which are widespread used especially in the regions of the North-East of the Country.

Beside the construction of medium-large capacity plants (between 100,000 and 200,000 tons biodiesel per year), particularly in areas of north-east initiatives are developing at small-scale to perform the energy self-sustaining of isolated rural communities. In the same time these initiatives aim to incentivise forms of familiar agro-industrial activities able to support local development and familiar income.

In this paper the results of a project focused on local biodiesel production and its use for energetic self-sufficiency of an internal community of Bahia State are reported.

2. Material and methods

The project has been activated since 2005. In a pilot plant, experimental runs for the treatment of local vegetable oils of different types and origins were developed. Among these there are castor oil, palm oil, soya oil, jatropha curcas oil, as well as several vegetable residual oils like exhausted frying oils. Experimental activities have been developed regarding the use of biodiesel in stationary engines and vehicles, as well the monitoring of the emissions quality [5].

In order to assist internal communities, in the Bahia State there are many rural communities many miles away from conventional energy sources and for which the construction of new power plants would entail a huge cost. An example is the community of Angical (13,500 inhabitants) displaced in the far west of the state where the area lack of urban and suburban streets and infrastructure for energy and water are very negligent. This creates serious problems of development and social inclusion. Angical was chosen to develop a pilot project to supply energy to isolated rural communities as a basic factor in encouraging the development of family activities and generally promote better living conditions. The project involves the exploitation of renewable energy sources, primarily biodiesel produced from castor oil, and in addition with the support of biogas, solar photovoltaic and wind energy. In Figure 1 the production cycle is reported; that consists in:

▪ a complex plant to produce biodiesel from castor oil composed by a central facility for the production of biodiesel for use in generators and also for transport and three satellite facilities suitable for the production respectively of castor oil, ethanol and cosmetics;
▪ a set of photovoltaic units serving households;
▪ a complex of wind systems for lifting water for irrigation;
▪ a complex of plants for the biogassification of organic wastes of various kinds to obtain biogas to be used for domestic refrigeration and in kitchens.

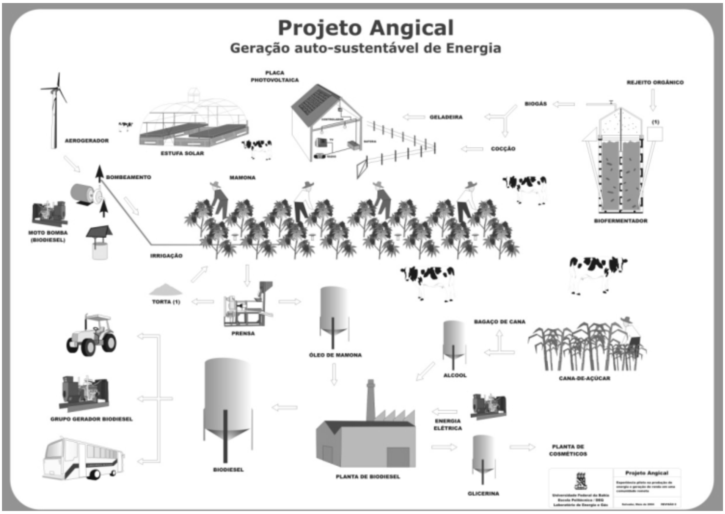

Figure 1 Poster representing the schematic layout of the Anglican project

The project is addressed to the support of the domestic energy consumption of the community and agro-industrial premises. The plant for the production of biodiesel is a small semi-continuous operation reactor, fed by castor oil and ethanol with KOH catalyst. The by-product of the reaction, glycerine, will be used for the production of cosmetics in one of three satellite facilities [6]. The choice of castor oil is determined by the finding that the State of Bahia (especially across the west-central area) is the more extensive area of Brazil suitable for the cultivation of the castor plant. The eligibility conditions are in fact:

▪ average daily temperature: between 20 and 30 °C;
▪ yearly rainfall exceeding 500 mm;
▪ good drainage characteristics of soil;
▪ altitude: between 300 and 1,500 m asl.

The project will be fully implemented once the program ProBiodiesel State of Bahia will have achieved the objective of disseminating local culture towards the development of plantations of castor oil, now spread throughout the area but in a spontaneous and random forms, and the local population will acquire the necessary technological readiness in the chain of converting oil into biodiesel and energy. It is not excluded that in the future orientation will prevail to another interesting oleaginous, the Jatropha curcas.

Industrial castor oil is obtained by pressing, hot or cold, seeds, obtaining a clear brilliant product with a maximum acidity of 1 % and 0.5 % of impurities and moisture [5, 7]. The main application of castor cake (the solid residue of pressing) is like having a fertilizer high in nitrogen. Another form of reuse is implemented as animal feed after the removal of residues of castor oil. Moreover, the leaves of the castor plant serve as food for silkworms and were also observed that the leaves mixed in the feed result in an increase in milk production of cows. The stem of the plant used to extract cellulose for paper making and also for obtaining fibrous materials for the production of coarse fabrics. The capacity of the plant for castor oil production is 1,350 L d^{-1}, while the capacity of biodiesel plant is 1,220 L d^{-1}.

As a complement to the Angical project, a pilot plant has been built in Salvador, Bahia, at a semi-industrial scale (capacity 5,000 m^3 y^{-1}), with the aim to experiment biodiesel production from different local vegetable oils. Figure 2 shows the pilot plant operating at Campus de Ondina, Universidad Federal da Bahia, Salvador, BA, Brazil.

This plant will also contribute to the scale up of new routes developed for the preparation of biodiesel, and tests fuel mixtures in vehicular and stationary engines in the evaluation of wear of engines and components, the study of photochemical reactions involving gases from vehicle emissions, the analysis and specification of raw materials, fuels and mixtures and co-products and acting in finding new applications for glycerine.

Other trend that has already been appropriated by UFBA through patent applications and is already being tested by Petro bras is the use of crude glycerine, co-product of the biodiesel production, for crude oil enhanced recovery.

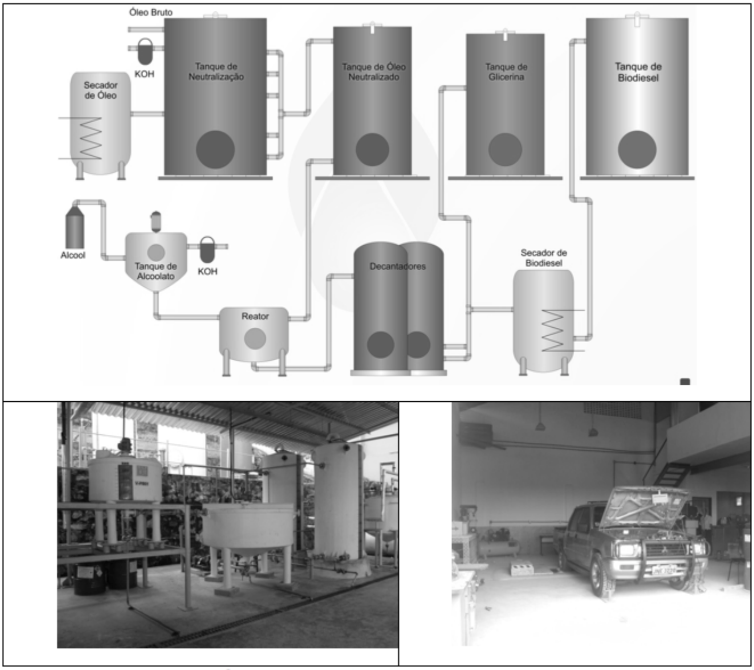

Figure 2 Pilot plants in Campus de Ondina (Universidad Federal Da Bahia), Salvador, with capacity of 5,000,000 L y-1

3. Results and discussions

In Brazil, an advantage of ethylic route may be the provision of alcohol throughout the country. Thus, the differential costs of freight, for the supply of ethanol versus methanol supply, in certain situations, might influence a decision. Under the environmental viewpoint, the use of ethanol has advantages over the use of methanol, alcohol when it is obtained from oil; however, it is important to consider that methanol can be produced from biomass, thus this supposed ecological advantage may disappear. Worldwide biodiesel has been produced via methanol [8]. Methanol is the alcohol predominantly used worldwide for the production of esters of fatty acids for use as biodiesel. Methyl esters of fatty acids are employed as biodiesel in most labs, tests in stationary engines, field tests and demonstrations. The reasons for this choice are due to the fact that methanol is by far the cheapest among the alcohols. However, ethanol is becoming more popular because it is renewable and much less toxic than methanol, is obtained from sugar cane, which is 100 % renewable and ensure greater safety in handling due to its lower toxicity [5]. The transesterification of ethanol for the production of biodiesel is a little more difficult than that of methanol due to the size of the molecule (higher). Still, due to the country's experience in producing and using this alcohol, large production capacity now in operation, and a consumer market and attractive for being less environmentally aggressive, ethanol arouses much interest among Brazilian producers. In Table 1 the comparisons between biodiesel and route via route methyl ethyl route is reported.

Table 1

Parameter	MeOH	EtOH
Quantity of alcohol per 1000 L of Biodiesel [kg]	90	130
Excess alcohol recommended [%]	100	650
Molar ratio alcohol: oil recommended	(6:1)	(20:1)
Recommended temperature [°C]	60	80
Reaction time [min]	45	90

Several factors such as availability, cost, storage properties and performance as fuel, which will determine the potential of a given raw material particularly for the commercial production of biodiesel. In some regions, most notably in Brazil, the availability of raw materials and technology allows for economically viable production of ethanol by fermentation processes, resulting in a product that is cheaper than methanol. In these areas, the nature of ethyl biodiesel is a product potential. One appealing aspect about the use of refined triacylglycerol feedstock, which is a determining factor for its selection as the predominant feedstock for biodiesel production, is the relative easiness with which they are converted to simple alkyl ester (biodiesel) by trans esterification chemistry. Attributes of raw material to be considered for biodiesel production are: content and quality of oil in the production per unit area; adapting to different production systems; and cycle of culture at regional adaptation. The raw materials for production of biodiesel are vegetable oils, animal fats, waste oils and fats. Vegetable oils and fats are mainly composed of triglycerides, esters of glycerol and fatty acids, monoglycerides or diglycerides. The term refers to the number of acids. In soybean oil, the predominant acid is oleic acid, babassu oil, the Laurid and beef tallow, stearic acid. Some sources for extraction of vegetable oil that can be used are: berry castor pulp, palm oil, almond coconut palm, almond coconut, babassu, sunflower seed, almond coconut beach, cotton seed, grain, peanut, canola seed, seed of passion fruit, avocado pulp, seed oiticica, linseed, tomato seed and turnip forrajeiro. While some native plants have good results in laboratories, as pequi, and buriti macaúba extraction and production is no commercial plantations to assess accurately their potential. That would take some time, since the research has not yet developed, national agriculture research focused in the field of botanical and agronomic cycles of these species. Among animal fats, we highlight the beef tallow, fish oils, oil calf's, the lard, among others; they are examples of animal fat with potential for biodiesel production. The residual oil and fat, resulting from processing domestic, commercial and industrial can also be used as feedstock. A survey of primary supply of waste frying oils, likely to be collected, shows a potential to offer the country more than 30,000 tonnes per year. Some possible sources of residual oil and fat are "cafeterias". In Table 2 some primary supply, with correspondent yearly production and use potentiality are reported.

Table 2

Type Oil	Content of Oilseed	Prod. [kg ha^{-1} y^{-1}]	Prod. Oil [kg ha^{-1} y^{-1}]
Animal Fats	100%	-	-
Jatropha	51%	5,900	3,000
Castor beans	50%	1,500	750
Sunflower	42%	1,600	672
Peanut	39%	1,800	702
Sesame	39%	1,000	390
Dende (palm oil)	20%	10,000	2,000
Soybean	18%	2,200	396
Cotton	15%	1,800	270
Babassu	6%	15,000	900

Some critical success factors for biodiesel in Brazil are: availability of oils and seeds and agricultural productivity; reducing the tax burden; quality of inputs and quality assurance of product; new uses for glycerine; efficiency and scale of process; performance engines; quality control at the pump; awareness and motivation of the society.

There are two types of biodiesel production on an industrial scale, the batch process (small quantities) and continuous process (for large quantities). From the technological point of view the best way to produce biodiesel would be via enzymatic catalysis, since it generates no glycerine, but otherwise this catalysis is becoming very expensive often unfeasible. In Brazil, the most popular technology for production of biodiesel is the homogeneous catalysis with alkali NaOH or KOH as a catalyst because it is cheaper.

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