

doi.org/10.32426/engresv5n1-001

Engineering Research

Technical Reports

Volume 5 – Issue 1 – Article 1

ISSN 2179-7625 (online)

BIODIESEL AND ITS STRATEGIC ROLE IN THE BRAZILIAN ENERGY MATRIX: A Literature Review

Pedro Paulo Andrade Júnior¹, Camila Almeida Martins²

JANUARY / 2014

Taubaté, São Paulo, Brazil

¹ Federal Technological University of Paraná - UTFPR, Brazil. E-mail: pedropaulo@utfpr.edu.br.

² Federal Technological University of Paraná - UTFPR, Brazil. E-mail: camila_amartins@yahoo.com.br.

Engineering Research: Technical Reports

Technical Editor: Giorgio Eugenio Oscare Giacaglia, Universidade de Taubaté, Brazil

Associate Technical Editors

Eduardo Hidenori Enari, Universidade de Taubaté, Brazil

Wendell de Queiróz Lamas, Universidade de São Paulo at Lorena, Brazil

Editorial Board

Asfaw Beyene, San Diego State University, USA

Bilal M. Ayyub, University of Maryland, USA

Carlos Alberto de Almeida, Pontifícia Universidade Católica do Rio de Janeiro, Brazil

Ciro Morlino, Università degli Studi di Pisa, Italy

Epaminondas Rosa Junior, Illinois State University, USA

Evandro Luís Nohara, Universidade de Taubaté, Brazil

Fernando Manuel Ferreira Lobo Pereira, Universidade do Porto, Portugal

Francisco José Grandinetti, Universidade de Taubaté, Brazil

Hubertus F. von Bremen, California State Polytechnic University Pomona, USA

Jorge Muniz Júnior, Universidade Estadual Paulista at Guaratinguetá, Brazil

José Luz Silveira, Universidade Estadual Paulista at Guaratinguetá, Brazil

José Rui Camargo, Universidade de Taubaté, Brazil

María Isabel Sosa, Universidad Nacional de La Plata, Argentina

Miroslava Hamzagic Zaratín, Universidade de Taubaté, Brazil

Ogbonnaya Inya Okoro, University of Nigeria at Nsukka, Nigeria

Paolo Laranci, Università degli Studi di Perugia, Italy

Rolando A. Zanzi Vigouroux, Kungliga Tekniska högskolan, Sweden

Sanaul Huq Chowdhury, Griffith University, Australia

Tomasz Kapitaniak, Politechnika Łódzka, Poland

Zeki Tüfekçioğlu, Ankara Üniversitesi, Turkey

The “Engineering Research” is a publication with purpose of technical and academic knowledge dissemination.

BIODIESEL AND ITS STRATEGIC ROLE IN THE BRAZILIAN ENERGY MATRIX: A Literature Review

Abstract. *This article aims to introduce biodiesel as a possible solution, describing its evolution in the Brazilian energy matrix. Ultimate conclusions claim that the use of biodiesel has several advantages, such as significant reductions in emission rates of greenhouse gases and a wide range of job creations and social inclusion in the poorest regions of the country. Furthermore, this article shows that, in a national scenario of growing imports of diesel oil and rising oil prices, biodiesel has become an interesting alternative of reducing imports of diesel and its derivatives, thus enabling the development of other industrial chains.*

Keywords: *Biodiesel, Biodiesel production, Socioeconomic and environmental analysis.*

1. INTRODUCTION

This article seeks to describe the evolution and impact of biodiesel production in the Brazilian energy matrix, observing its influence on the growth of renewable energy for socioeconomic and environmental development.

This phenomenon observed in many countries over the last decade can be explained by its positive effects, such as enabling disadvantaged countries to make innovative products and services with great potential; stimulating scientific and technological progress; encouraging exports of cleaner energy, awakening for environmental awareness, generating new skills and qualifications and contributing to the generation of employment and income.

Aiming to enter this ever-changing competitive context, Brazil has stimulated the use and production of renewable energies in the Brazilian energy matrix through biodiesel production, thus providing environmentally cleaner fuel through partnership projects with universities, the government and the private sector

Petroleum products are one of the main sources of energy used worldwide. However, high oil prices resulting from the crisis in the 70s and 80s as well as from environmental, economic and social consequences of the intensive use of non-renewable sources of energy encourage the search for biofuels.

The study of alternative energy for socioeconomic development and environmental sustainability in Brazil dates from the 1920s. The country's dependence on oil is obvious for fuels like gasoline and diesel, crucial for the transport of loads or passengers.

In this context, fuel obtained from agricultural products offer an interesting alternative. Following the success story of ethanol as alternative fuel to gasoline, biodiesel is outstanding.

Initially considered a substitute for traditional diesel vegetable oil "in nature", this alternative proved to be impractical due to its high viscosity causing disadvantages, such as carbon deposits in cylinders and injector.

The idea of adding it to petroleum-based fuels to form a mixture, which can be used in compression ignition engines (diesel) without changes was the solution.

In 2004 the National Program for Production and Use (Programa Nacional de Produção e Uso de Biodiesel - PNPB) was launched to ensure biodiesel production, both for regional development and social inclusion.

By Law No. 11097 from 13 January 2005, the PNPB authorized the introduction of biodiesel into the Brazilian energy matrix, determining the optional use of B2 (2% biodiesel added to diesel oil) until 2008, this being mandatory plus the optional use of B5 between 2008 and 2013, and B5 being mandatory thereafter.

However, in 2010 diesel fuel sold in Brazil started to contain 5% biodiesel, this percentage increasing steadily over the years.

The use of biodiesel as fuel is increasingly supporting governmental policies in environmental and social areas. This has generated economic advantages, such as the use of its byproducts and the possible reduction of diesel oil imports.

In the context of global search for alternative energy leading to socioeconomic development and environmental sustainability, and due to increasing imports of diesel fuel amid rising oil prices, biodiesel has become an interesting alternative.

Brazil has adopted a national policy of gradual increase of the percentage of biodiesel added to regular diesel for the development of biofuel, aiming to stimulate production and bring social and environmental benefits.

However, the rapid development of biodiesel production in Brazil in recent years has not been accompanied by judicious procedures able to find out, consistently, the role it could be playing in the Brazilian energy matrix.

In this sense, studies point to the need for performing and verifying scientific research in order to formulate the conditions under which the agents involved in the biodiesel production system stay competitive with the global market. This leads to the following question: **How to check production and development of the use of biodiesel in the Brazilian energy matrix?**

2. METHODOLOGY

Scientific knowledge production results from surveys, which require the adoption of a

method to assist the researcher in the creation, development and completion of the work (YIN, 2005).

Firstly, a literature review was conducted with primary and secondary research sources, to direct and conduct the research, which required a theoretical conceptualization of the problem and an examination of the literature proposed.

After exhaustive literature review, consistent basis of knowledge was formed. Considering this study question, its goals and the information available on the subject, it was found that the qualitative approach seemed to be more appropriate to conduct research. Especially because qualitative approach seems to be the right way to understanding and measuring the nature of the phenomenon of biodiesel production.

According to Smith (2005), exploratory research “is the poll, survey, discovery, research and speculation”. The author argues that the first stage of any study is to leave the research problem more explicit, creating hypotheses, by improving your mind or intuition, and can be either by literature as by analyzing models (case studies).

It was adopted an exploratory study because it does not elaborate hypotheses to be tested at work, restricting themselves to set goals and to seek information about a particular subject. The exploratory study aims to familiarize the subject with accurate descriptions to get a new insight or even discover new ideas and connections between components (CERVO and BERVIAN, 2002).

For this purpose, were carried out accurate descriptions of biodiesel state. Thus, the paper also presents descriptive characteristics, as notes, records, analyzes and correlates facts or phenomena without manipulating or modifying them (CERVO and BERVIAN, 2002; RUDIO, 2003).

According to Silva and Menezes (apud Gil, 2001), from the standpoint of technical procedures, a literature research is that one prepared based on previously published in scientific literature, including books, journal articles, as well as materials available on the Internet.

Thus, the article may be considered exploratory in nature using the literature search, for this purpose. For summarize, analyze and discuss information already published on the subject, the article may be considered, according to Silva and Menezes (2001), a review article.

Silva and Menezes (2001) argue about the importance of conducting a research method so that it becomes faster and bring better results. Adopting this idea, after choosing a theme that seemed to be relevant in scientific terms, it was elaborated a work plan, in which stood the subject's issues to be addressed. This plan served as a guide in this process of information collection and reading. Then, the materials were identified, analyzed and filed, thereby allowing the collection of necessary and useful information. With the indexed material, the information collected was classified, analyzed and interpreted.

First it was made a literature review on the concept of biodiesel, always trying to gather as many definitions for the best understanding of the theme. Through the literature review, it was possible to analyze publications on the subject and information about the current status of biodiesel in Brazil and around the world and to read different opinions about the theme. Then, the subject was conceptualized through a historical review and through a current overview of biodiesel in Brazil, presenting an analysis of the evolution of its studies.

Qualitative research was also adopted through Internet research, analysis of government reports, tables, graphics and consulting academic papers related to the topic.

This article was developed by addressing social, environmental and economic factors of this biofuel, showing its main strengths and weaknesses within each aspect analyzed. The environmental and economic issues were justified based on recent statistics. After presenting some practical examples of success, the article is ended with a conclusive overview, containing an analyze of its major benefits for Brazil and how some of their advantages can be a differential for the development of specific country's regions.

3. BIODIESEL

Biodegradable fuel such as biodiesel can come from many different types of vegetable or animal oils, "in nature" or as waste, and has physical and chemical characteristics similar to diesel oil. Among the most common renewable sources are oilseeds such as soybeans, oil palms, castor beans and sunflowers, and some still little diffused sources such as jatropha. Depending on the feedstock used, the physical and chemical oil characteristics may vary smoothly (NETO et al., 2004).

This biofuel can be produced in three different ways: cracking, esterification and transesterification. The most currently used is transesterification, which is the reaction between vegetable oil and an active intermediary. This intermediary is the reaction product of an alcohol (usually ethanol or methanol) with a catalyst (Parente, 2003).

According to Law No. 11,097, biodiesel can be conceptualized as "biofuel derived from renewable biomass for use in internal combustion engines with compression ignition or, in accordance with regulations, to generate another type of energy that can partially or totally substitute fossil fuels."

Biodiesel can be added to petroleum fuels forming a mixture which can be used in compression ignition engines (diesel) without change.

Another definition was established by the National Petroleum Agency (Agência Nacional do Petróleo - ANP) by means of Article 2 of the ANP Resolution No. 42 of 24.11.2004:

I - biodiesel - B100 - fuel composed of alkyl esters of long-chain fatty acids,

derived from vegetable oils or animal fats as the specification contained in the Technical Regulation No. 4/2004, part of this Resolution;

II - mixed diesel / biodiesel - B2 - commercial fuel composed of 98% by volume of diesel fuel, as specified by the ANP, and 2% by volume of biodiesel, which meets the specification provided by the ANP No. 310 of 27 December 2001 and its amendments. (NATIONAL AGENCY OF PETROLEUM, 2005)

Chemically, biodiesel is a mixture of mono-alkyl esters of fatty acids. Its most common process is transesterification, in which a triglyceride reacts with a short-chain alcohol in the presence of an acid or basic catalyst, obtaining, as a result of fatty acid esters, methyl or ethyl (biodiesel) and glycerin (MONTEIRO and MUÑOZ, 2011).

Biodiesel is technically viable as a fuel and has possible advantages over petroleum-based fuels. One of these advantages is the fact that it generates lower environmental impact and is made from renewable sources (Getulio Vargas, 2005). Moreover, it has high potential for biodegradability and low toxicity (Meyer, 2011).

4. HISTORY OF BIODIESEL IN BRAZIL

Vegetable oils used as fuel is no news. Biodiesel has been studied since the nineteenth century, especially in Europe. According to historical records, the inventor Rudolf Diesel introduced the diesel engine in 1900 in Paris, using peanut oil-based fuel. According to the Portal Biodiesel (2006a) made by the government, Diesel reportedly stated, in 1911, that "the diesel engine can be fed with vegetable oils and will considerably help agriculture develop in countries that will use it."

Because of its high viscosity pure vegetable oils have disadvantages such as carbon deposits in cylinders and nozzles. Surveys resulted in the discovery of the transesterification process, patented by the Belgian scientist G. Chavanne in 1937, thereby not mentioning the need for any changes to the engines (PLA, 2005).

In later years, fossil oil was abundant and affordable determining the use of its derivatives as fuel. Fossil oil, however, went through periods of falling production and supply, such as the crises in the 70s and 90s, encouraging the search for alternative energy sources (Souza et. Al., 2009).

In the 70s, according to the Portal of Biodiesel (2006a), the Federal University of Ceará, along with Professor Expedito Parente, obtained a patent for the manufacture of biodiesel, which expired without the country adopting biofuel. At that time, priority was given to PROALCOOL policy, implemented in 1975.

Biodiesel has been produced on a pilot scale in Brazil since the 80s. At that time, experiments were performed using different oilseeds for biodiesel production, and different contents

of this biofuel in the traditional diesel (Souza et al., 2009).

In 1998, areas of research and development projects in Brazil regained the use of biodiesel. By Decree No. 702 of October 30, 2002, the Ministry of Science and Technology (Ministério da Ciência e Tecnologia - MCT) created the PROBIODIESEL, with the goal of using vegetable oils transesterified in the national energy matrix. According to Cezar Menezes Almeida (2006) this program aims at developing production technologies and harmonizing actions for the development of biodiesel as well as at approving of technical specifications and attesting its economic, social and environmental viability and competitiveness. Therefore, it has a differentiated approach in relation to PROALCOOL aimed primarily at power supply, thus not having social and environmental issues as important factors in decision-making (Lima, 2004).

By Decree from July 2, 2003 the Federal Government established the Interministerial Working Group, which studies the viability of biofuels and take necessary actions for its implementation. In the same year, the Brazilian government created the Interministerial Executive Commission (IEC) and the Management Group (GG), by Presidential Decree from December 23, 2003, charged with implementing actions for biodiesel production and use (RATHAMANN et al. in 2005).

The following year saw the release of the National Biodiesel Production and Use (PNPB) on December 4, 2004, having as main objective to ensure biodiesel production, also aiming at regional development and social inclusion. By Law No. 11097 from January 13, 2005, the PNPB authorized the introduction of biodiesel into the Brazilian energy matrix and increased the administrative jurisdiction of the ANP, which is now called the National Agency for Petroleum, Natural Gas and Biofuels. After the publication of that law "the ANP took the assignment of regulating and supervising activities related to production, quality control, distribution, sale and marketing of biodiesel and diesel-biodiesel mixture (BX)" (ANP, 2011).

In addition, Law No. 11097 ruled the optional use of B2 (2% biodiesel added to diesel oil) until 2008, then mandatory and optional use of B5 between 2008 and 2013, B5 use being mandatory thereafter.

5. CURRENT OVERVIEW OF BIODIESEL IN BRAZIL

Although Law No. 11,097 declares the mandatory use of B5 only from 2013, diesel fuel sold in Brazil has already contained 5% biodiesel since January 1, 2010. This rule was established on October 26, 2009 by Resolution No. 6/2009 of the National Energy Policy (CNPE). This percentage will be increased steadily over the years, the ANP authorizing, regulating and watching its trade (ANP, 2011).

In 2010 Brazil became the second largest producer of biodiesel in the world, second only to

Germany (Figure 1). And in 2011 it became the largest consumer of fuel among all countries (Ministry of Mines and Energy, 2011).

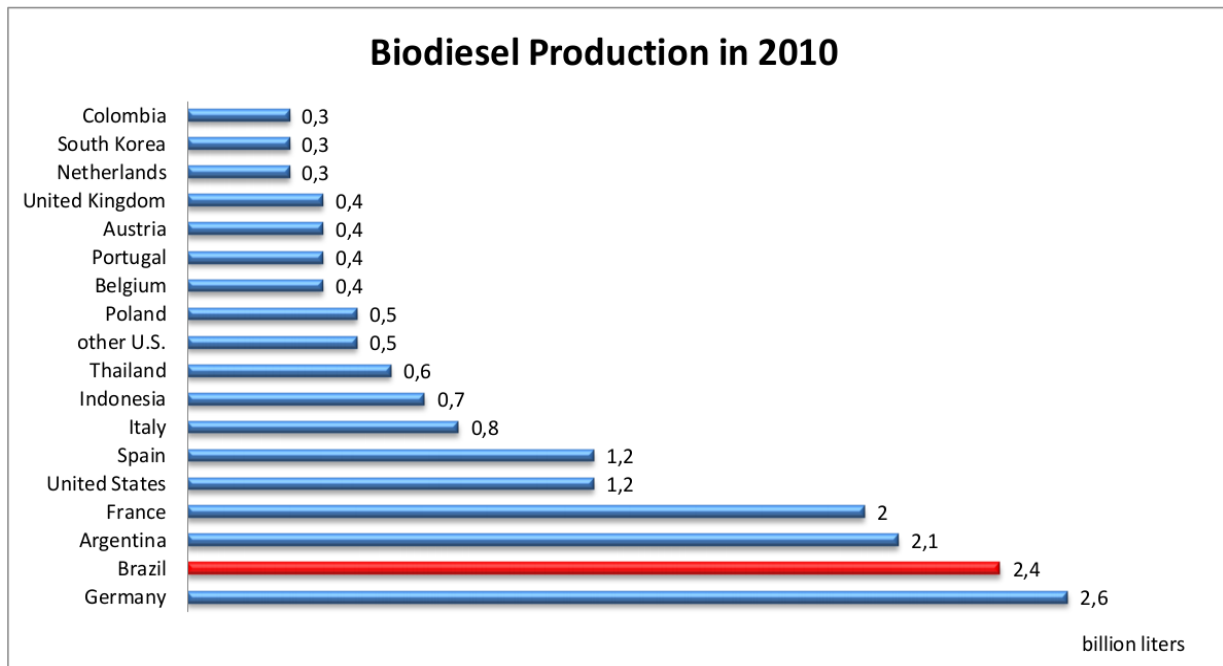


Figure 1 - Production of Biodiesel in 2010 (MME, 2011)

In some cities in the country even B20 is already a reality. According to the Brazilian Biodiesel Union (União Brasileira do Biodiesel - UBRABIO), an example of a city that is investing in the use of biodiesel in public transportation is Sao Paulo. The so-called Ecofrota, the largest fleet of the country moved by B20 has about 3,070 buses on 200 lines in use. Since 2009, the fleet of urban public transportation of Curitiba has been using Biodiesel. In March 2011 a new model bus, the Mega BRT, fueled by B100 was launched in the city.

5.1. Environmental, Social, and Economic Overview

The use of biodiesel as fuel is more and more becoming a support for governmental environmental and social policies.

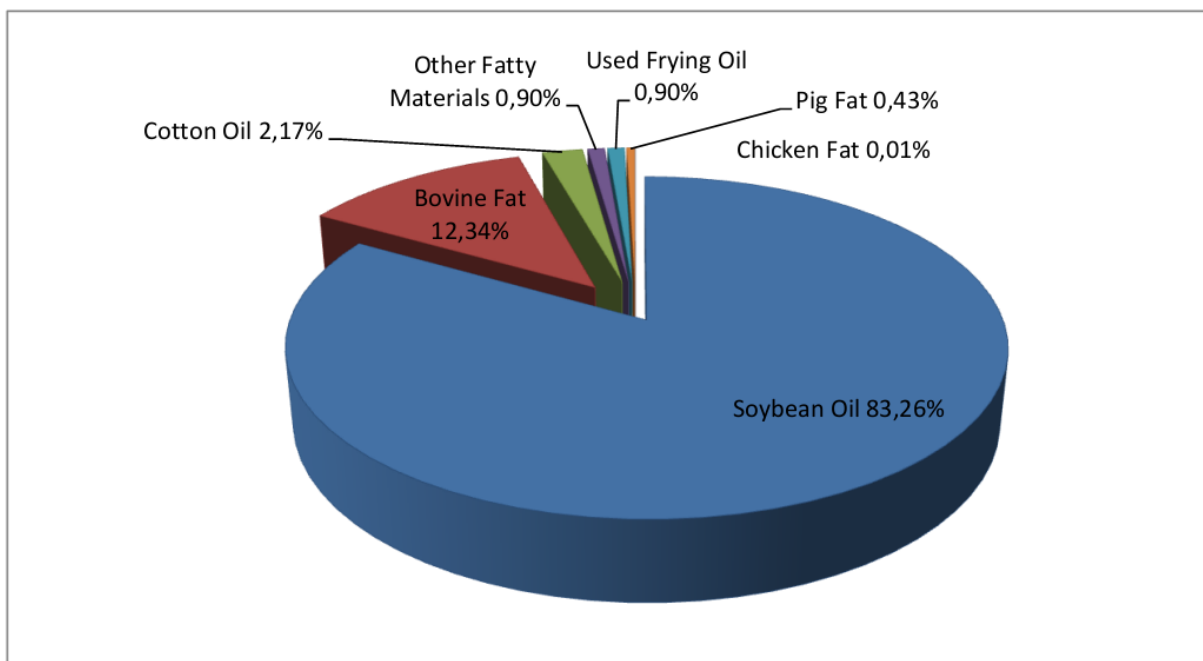
The reduction of some greenhouse gas emission rates has already been recognized, resulting in improvements of life quality and public health. Although the use of biodiesel generates an increase in nitrogen emission compounds, it reduces pollutants such as hydrocarbons, carbon monoxide, sulfur oxides, aromatic hydrocarbons and carbon dioxide, compared to diesel fuel oil.

The Environmental Protection Agency believes that the use of B20 in large cities provide a reduction of about 20% in hydrocarbon emission additional to 10% in particulate materials and carbon dioxide. According to the same agency, B100 can reach 57% reduction in carbon dioxide emissions (UNIBRAS, 2011).

Beside its positive effect on the environment, this reduction avoids governmental spending on public health estimated at \$ 900 m per year. It is also important to mention that renewable fuel production favors international financing in carbon credit markets under the Kyoto Protocol (ANP, 2011).

From the social point of view, biodiesel production has promoted land unsuitable for food production, has diversified the Brazilian energy matrix and created jobs and income in rural areas, thus contributing to social and regional inequalities.

The great biodiversity of Brazil as well as various types of climates and soils throughout its territory make it extremely rich in vegetable oil sources. In this context, to tap the full regional potential, develop family farming in areas where underdevelopment is critical and generate job alternatives in areas unattractive to other economic activities, the diversification of raw materials used to produce biodiesel has gained relative importance. However, according to ANP, in June 2011, 83.26% of biodiesel produced in the country was made of soybeans (Fig. 2).



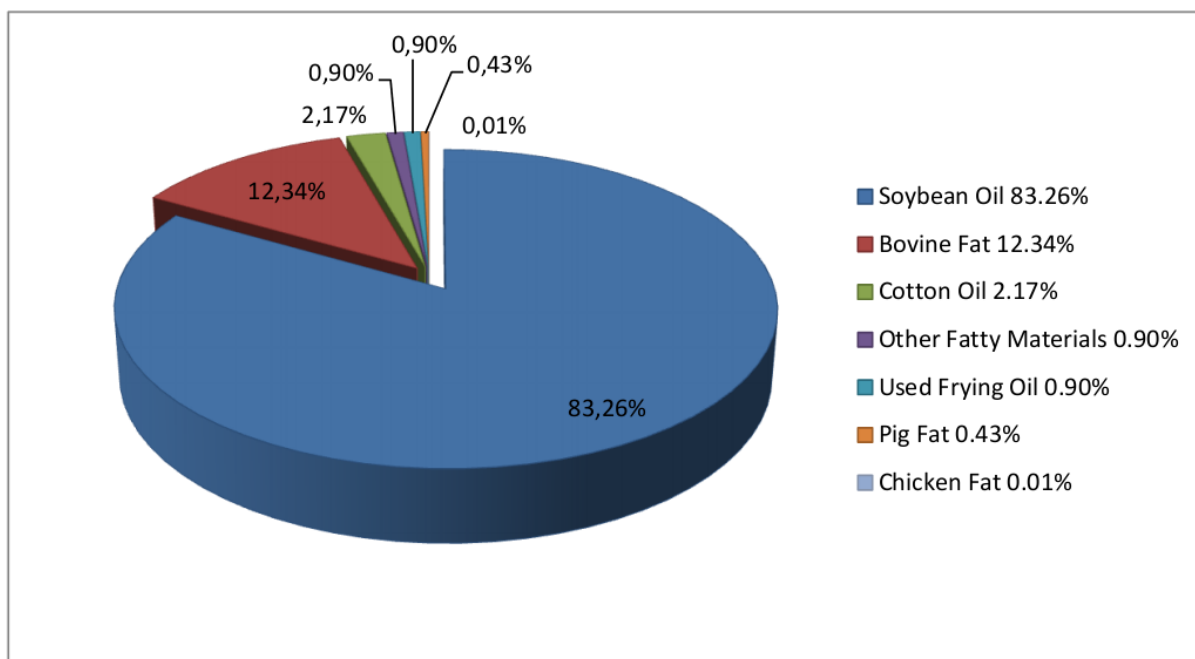


Figure 2 - Raw Materials Used in Biodiesel Production (ANP, 2011)

It is undeniable that soy has a very important role for biodiesel production. However, this agrarian culture is already consolidated in the South (region with the largest capacity for its development), and so does not meet the social objectives of the program.

The best alternatives for achieving social inclusion in the poorest areas of Brazil are castor beans in the Semi-Arid, since they have high oil content and are adapted to regional conditions, and palms in the North produced by peasant families (UNIBRAS, 2011).

To support family-run farming, the government created the Social Fuel Seal. This certificate is awarded to manufacturers who buy raw material from farmer families, providing tax exemptions and access to better financing conditions (CARTILHA DO GOVERNO FEDERAL, 2007).

Despite all advantages and the great advance of biodiesel in Brazil, the economic viability for commercial use requires more detailed analyses.

To be economically viable, biodiesel must be competitive with low oil prices. Currently, production costs of fossil diesel are so low that biodiesel is not worth producing. However, this situation is beginning to change due to abrupt changes in crude oil prices.

The competitiveness of biodiesel tends to increase more as the fall in the price of raw materials, vegetable oil and alcohol is consolidated. Supply expansion based on the improvement of farming technology and the efficiency of supply chains leads to cheaper vegetable oil accounting for the major part of the costs of biodiesel.

Another significant reason is the possibility of reducing production costs of biodiesel through the use of its byproducts, as has occurred with ethanol. The main byproduct of biodiesel is glycerin; however, its production chain generates a series of other, less widespread byproducts. The

castor bean, for example, generates byproducts such as pie, i.e. its pulp for animal feed, in the business market of agricultural fertilizers; its stem for paper and coarse fabric production, and soybean meal. The use of this renewable fuel improves the prospect of reducing diesel imports, generating foreign currency for the country, and thus reducing dependence on oil.

According to the Ministry of Mines and Energy, in 2010 Brazil imported a monthly average of about 751 000 m³ of diesel, which represents an increase of more than 150% over 2009, when the average was about 290 000 m³. Between January and May this year, a monthly average of 511,000 m³ of diesel fuel was imported, equivalent to almost 20% reduction over the same period last year when an average of 626.4 thousand m³ per month was recorded.

Despite the data presented, a study conducted at the end of last year by the Getúlio Vargas Foundation (Fundação Getúlio Vargas - FGV) showed that the country no longer spent \$ 2.84 billion on imports of diesel between 2005 and July 2010, thanks to the use of biodiesel blends.

Thus, adding a higher percentage of biodiesel to fossil diesel proved to reduce the deficit in the Brazilian trade balance due to growing consumption of this fuel. Not before 2010 Brazil avoided importing 2.5 billion liters of diesel by adopting B5. According to the Social Communication (UBRABIO), the mandatory use of B10 would reduce diesel imports by about 30%.

Taking into account the fact that biodiesel is more expensive than regular diesel, it was necessary to introduce a model that avoided direct competition between these two fuels within the rules of conventional markets so a specific market for biodiesel was structured. In this context, auctions organized by the ANP regulate the prices of the product and ensure its offering, aiming to generate markets and stimulate its production in sufficient quantity so that refiners and distributors could compose the mixture determined by law (ANP, 2011) .

A success in biodiesel production, according to UBRABIO, is Fertibom. A company of the agribusiness sector, it has its own technology of producing from various raw materials, and a database with more than 3000 formulations of ethanol. It presents an annual production capacity exceeding 120 million liters. Another example is the JSB Biodiesel with a production capacity, both from vegetable oils and animal fats, of 201,600,000 liters per year. It has a fully-automated production system and laboratory testing to provide for the quality of biofuel.

Some examples of international companies in growth in the area are the German Binatural and Fiagril, in addition to the producer of raw materials Evonik Degussa and the equipment supplier Dedini. The latter maintains a laboratory in Belgium for research in and testing of raw materials, and a pilot plant in Rome for continuous production, where process improvements, new raw materials, additives and reagents are tested.

Germany, currently the world's largest producer, has about 2000 points of sale of biodiesel, distributing B100 biodiesel in its pure form, without any mixing or additives. At service stations in

the country, one pump has two nozzles, one for fossil diesel and another with green seal for biodiesel, about 12% cheaper. Thus, users can mix this biofuel with regular diesel, in various proportions. This high competitiveness of biodiesel compared to fossil diesel was basically due to tax exemption on its entire supply chain, as well as to a solid logistics infrastructure of the country. Given this development as well as tax, legal and environmental issues, carmakers have adapted their vehicles to receiving this fuel, and engine manufacturers have ensured the quality of their product yield (ROZA and Freitas, 2010. Soares, 2010).

Other successful experiments, but with less emphasis, are France now using a B30-mixture in fleets of public transport, and Austria exempting of tax pure biodiesel of about 95% , additionally using B100 in public transport (Soares, 2010).

6. CONCLUSION

This article aimed to assess production and development of the use of biodiesel, seeking to understand renewable energy actions with reference to the Brazilian energy matrix.

To meet this goal, the article initially rescued major theoretical and empirical approaches in the area of biodiesel production. After reviewing literature and relationships between these different areas of knowledge, the article seeks to analyze the current situation of biodiesel in Brazil, with focus on environmental, social and economic conditions.

Understanding these dimensions underlying biodiesel production can contribute to a more realistic formulation of policies enhancing the Brazilian energy matrix.

The development of biodiesel as an alternative, oil-replacing energy was marked by uncertainty and projects with long maturity, with a strong presence of the Government as a funder and performer of actions for implementation. Initially high production costs of biodiesel compared to those of fossil diesel were barriers to the production and use of biodiesel. However, the study showed that rising international oil prices have facilitated its use.

In the short-term, Biodiesel can be an alternative to conventional fuels. Not only are production practices of raw materials well spread but also technologies for biodiesel production already available in industrial units.

The growing use of biodiesel in the Brazilian energy matrix has created positive expectations of change in social, environmental and economic conditions.

However, studies indicate the need for performing and verifying future scientific research. This will help establish the conditions under which the agents involved in the production system of biodiesel may evaluate their difficulties, so they remain competitive to the global market and, thereafter, create actions that can maximize their results.

The increased competitiveness of biodiesel depends on factors such as rising oil prices,

B100 price reductions through the use of by-products, and production chain development. Gradually, the increased production of biodiesel is reducing the need for diesel imports as well as the country's dependence on fossil oil.

An important limitation, perhaps the main limitation, for the Brazilian biodiesel market is its price. This factor takes the competitiveness of the product and prevents biodiesel from competing directly with fossil diesel, so there is need for mixing. The mixture in low percentage does not cause a strong impact on the final price of diesel.

The South and Midwest regions of the country present themselves as particularly conducive to economic growth resulting from the use of biodiesel. Since they have been developing grain cultivation intensely, they account for over 60% of soy production capacity, soy being the main raw material used for the production of this biofuel.

Although the role of soy in biodiesel production is undeniable, this crop is already consolidated in the regions mentioned, therefore showing no significant social benefits.

Crops such as castor and palm oil in the Northeast and North of Brazil, produced by family-run farms, have become the best alternative for achieving social inclusion in the poorest areas of Brazil and creating alternative jobs in areas not conducive to other economic activities.

Oilseed cultivation for biodiesel production on small farms and fuel production in various industrial units spread throughout the country allow for increased social benefits (LIMA, 2005). This aspect shows the social character of the development of biodiesel, with the participation of family-run farming in the process, generating income and employment in agriculture, especially in poor and remote regions.

Apart from valuing oilseeds as raw materials cultivated in the country, biodiesel production has strengthened a new chain, generating income and jobs in agriculture and in the markets for inputs and services.

Thanks to long-term strategic vision coupled with the experience gained from research into alternative renewable energy sources, the country is able to implement production, with the possibility of attracting investors by aligning itself to meet the requirements of international agreements, such as the Kyoto Protocol, and to trade Carbon Credits (BRASIL, 2005).

Investing in research projects for the stimulation of biodiesel production from crops with regional importance will contribute to both the formation of matrix production in Brazil and the generation of employment and income, and will make biodiesel a vector of regional development by creating new skills and qualifications.

To meet the growing demand, it would be important to continue implementing measures to leverage a national project of biodiesel with public policies stimulating production and consumption through tax incentives, environmental awareness of consumers and regulation of biodiesel

production. Assuring consumers of standardization and quality as well as meeting international specifications are further main aims for the development of the promising export market for renewable energy.

This article highlights the rapid development of biodiesel in Brazil and its relevance in search of socioeconomic development and environmental sustainability, necessary and of growing importance in today's world. As a result, this study is expected to offer unique benefits to institutions regulating biodiesel production chains, ensuring consumer markets and coordinating production and marketing, and to support them in their decision-making on actions of improvement.

Finally, this study is of importance for both academic researchers and those involved in the biodiesel production system, raising environmental and economic awareness. Apparently, it will help overcome the lack of current data on biodiesel production, on the Brazilian energy matrix, and on the decisive role of agents involved, thus providing support to the formulation of improvement actions and redirect actions.

REFERENCES

AGÊNCIA NACIONAL DE PETRÓLEO, GÁS NATURAL E BIOCOMBUSTÍVEIS (ANP)

Available: <www.anp.gov.br> Accessed August 2011.

BRASIL, Câmara dos Deputados. O Biodiesel e a Inclusão Social. Conselho de Altos Estudos e Avaliação Tecnológica: Relatório do Deputado Ariosto Holanda. Centro de Documentação e Informação - Coordenação de Publicações Brasília, 2004. Available: <<http://www.camara.gov.br/internet/infdoc/Publicacoes/html/pdf/Biodiesel02.pdf>>, Accessed August 2012.

CARTILHA DO GOVERNO FEDERAL. Biodiesel: o novo combustível do Brasil. Programa Nacional de Produção e Uso de Biodiesel (PNPB). [2007]. Available: <http://www.biodiesel.gov.br/docs/Folder_biodiesel_portugues_paginado.pdf>. Accessed August 2011

CERVO, A. L.; BERVIAN, P. A. Metodologia Científica. 5ª ed. São Paulo: Pearson Prentice Hall, 2002.

Lei Nº 11.097 de 13 de Janeiro de 2005. Dispõe sobre a introdução do biodiesel na matriz energética brasileira; altera as Leis nos 9.478, de 6 de agosto de 1997, 9.847, de 26 de outubro de 1999 e 10.636, de 30 de dezembro de 2002; e dá outras providências., Presidência da República, Brasília-DF. 2005b.

LIMA, P. C. R. Biodiesel: Um Novo Combustível para o Brasil. Consultoria Legislativa: Fevereiro/2005. Disponível em: <<http://www2.camara.gov.br/publicacoes/estnottec/tema16>>, Accessed August 2012.

- MEYER, Daniel Derrossi. Avaliação da biodegradabilidade de misturas de diesel e de biodiesel (B0, B20 e B100) em dois solos com diferentes granulometrias. 2011. 146 f. Dissertação (Mestre em Microbiologia Agrícola e do Ambiente) - UFRGS, Porto Alegre, 2011.
- MEIRELLES, F. S. Biodiesel. Serviço Nacional de Aprendizado Rural. Brasília, 2003 Available: <<http://www.faespsenar.com.br/faesp/economico/EstArtigos/biodiesel.pdf>>, Accessed August 2012.
- MINISTÉRIO DA CIÊNCIA E TECNOLOGIA. Programa brasileiro de biocombustíveis: rede brasileira de biodiesel - PROBIODIESEL. Brasília, 2002.
- MINISTÉRIO DAS MINAS E ENERGIA. Balanço Energético Nacional 2010. Brasília, DF, 2006. Available: <<http://www.mme.gov.br>> Accessed August 2011.
- MONTEIRO, M. A. N. A.; MUÑOZ, R. A. A. Método Voltamétrico Para Determinação De Cobre Em Biodiesel Após Extração Em Banho De Ultrassom. Available: <<http://www.seer.ufu.br/index.php/horizontecientifico>> Accessed August 2011.
- NETO, José Adolfo Almeida; ALMEIDA, César Menezes; PIRES, Mônica de Moura. Biodiesel: uma análise econômica e ambiental, 2004, João Pessoa-PB. IX Seminário Integrador - Ética, Desenvolvimento e Meio Ambiente. João Pessoa-PB: Prodema/UFPB, 2004.
- PARENTE, E. J. S. Uma aventura tecnológica num país engraçado. Available: <<http://www.iadb.org/intal/intalcdi/PE/2008/01430.pdf>> Accessed August 2011.
- PLÁ, J. A. Existe viabilidade econômica para o biodiesel no Brasil? Indicadores Econômicos FEE, Porto Alegre, v.32,n.4, p. 271-294, mar. 2005
- PORTAL DO BIODIESEL. Available: < www.biodiesel.gov.br> Accessed August 2011.
- RATHAMANN, R.; SANTOS, O. I. B.; PADULA, A. D. ; PLÁ, J. V. J. A. Biodiesel: Uma Alternativa Estratégica Na Matriz Energética Brasileira? Página Oficial do Biodiesel do Governo Federal do Brasil. Brasília - DF 2005.
- ROZA, Felipe Costa; FREITAS, Livia Silva. Balanço das emissões de gases do efeito estufa (GEE) na cadeia completa de produção do biodiesel de soja. 2010. 142 f. Tese (Engenheiro Ambiental) - Curso de Engenharia Ambiental, Departamento de Escola Politécnica, Universidade Federal do Rio de Janeiro, Rio de Janeiro, 2010.
- RUDIO, F. V. Introdução ao projeto de pesquisa científica. Rio de Janeiro: Editora vozes, 2003.
- SOARES, Nuno Manuel Vicente Esteves. Valorização dos Óleos Alimentares Usados para Produção e Utilização de Biodiesel à Escala Municipal: Estudo de Caso – Conselho de Mafra Análise Energética, Ambiental e Econômica da utilização de Biodiesel vs. Gasóleo na frota municipal. 2010. 87 f. Dissertação (Mestre em Engenharia do Ambiente) - Departamento de Instituto Superior de Agronomia, Universidade Técnica de Lisboa, Lisboa, 2010.
- SOUZA, Luis Fernando Gomes; FIORESE, Diego Augusto. Avaliação econômica da produção e

utilização de biodiesel a partir de fontes vegetais e animais. Available:
<<http://www.fag.edu.br/graduacao/agronomia/csvolume2/14.pdf>> Accessed August 2011

SIQUEIRA, Marli Aparecida da Silva. Monografias e teses: das normas técnicas ao projeto de pesquisa. Brasília: Consulex, 2005.

SILVA, Edna Lúcia da; MENEZES, Estera Muszkat. Metodologia da pesquisa e elaboração de dissertação. 3. ed. rev. atual. Florianópolis: Laboratório de Ensino a Distância da UFSC, 2001. 121p.

UNIÃO BRASILEIRA DO BIODIESEL (UBRABIO). Available:
<<http://www.ubrablo.com.br>> Accessed August 2011

YIN, R. K. Estudo de caso: planejamento e métodos. 3ª ed., Porto Alegre: Bookman, 2005.