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The emergence of the biodiesel industry in Brazil: Current figures and future prospects

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ABSTRACT

The aim of the present paper is to characterize and analyze the emergence of the biodiesel industry in Brazil, and provide an assessment of the extent to which the goals established by the National Biodiesel Production and Usage Program have been reached. In relation to the goal of including biodiesel within the Brazilian energy matrix, the program can be seen to be responding dynamically and ahead of schedule. In 2010, the B5 blend was already part of the diesel consumed in Brazil, with 81% of the biodiesel coming from soybean oil and 14% from beef tallow. By contrast, the plans to diversify the feedstocks used to produce biodiesel and improve production in the poorest regions of Brazil have failed to prosper. Regarding the goal of fostering social inclusion by encouraging the participation of family-based farming, this has been partially achieved. Finally, the goal of cost-efficiently producing biodiesel is far from being achieved. The economic feasibility of the production and use of biodiesel in Brazil can be questioned since it is still strongly supported by tax incentives and production and marketing subsidies.

1. Introduction

Motivated by the search for sustainable sources of liquid fuels, the replacement of fossil fuels, and the need to reduce greenhouse gas emissions, biomass have been gaining importance in the energy matrix in several countries (Matsumoto et al., 2009; Matsumura and Yokohama, 2005; Tsai, 2009; Becker et al., 2011). In their study of bioenergy policies in different countries, Sorda et al. (2010) found that the production of biofuels has been largely guided by government policies in recent decades.

In 2010, the share of renewable energy in Brazil's energy matrix was 47.5%. Of these renewable sources, 29.6% came from biomass (MME, 2011a). With the experience gained in implementing the National Ethanol Production Program (*PROALCOOL*) during the 1970s, in December 2004 the Brazilian government launched the National Biodiesel Production and Usage Program (PNPB) with the aim of encouraging the introduction of this biofuel into the national energy matrix (Casa Civil, 2005).

Considering Brazil's continental dimensions and climatic, soil, and socioeconomic diversity, the guidelines contained in the PNPB call for the introduction of technically, socioeconomically and environmentally sustainable production and use of biodiesel, with a focus on social inclusion and regional development through the generation of employment and income. These guidelines are managed within a regulatory framework that provides tax incentives that favor the inclusion of family farming, the diversification of feedstocks and the development of the poorest regions in the production of biodiesel.

As from January 2005 (Law 11.097/05), refiners and distributors were allowed to add 2% biodiesel to diesel (B2). In 2008, that percentage became mandatory and due to the rapid response from the supply side, the government transformed B5 into a mandatory blend in 2010. Following the implementation of the PNPB, between 2005 and 2011 there was a significant increase in the volume of biodiesel produced in the country, which rose from 736 m^3 in 2005 to 2.39 million m^3 in 2010, making Brazil the world's second largest biodiesel producer.

Although there are several studies on the production of bioenergy in different countries (Matsumoto et al., 2009; Matsumura and Yokohama, 2005; Tsai, 2009; Becker et al., 2011; Rathmann et al., 2011), the particular, socio-economic, productive and institutional conditions of Brazil and the design of the PNBP's regulatory framework may provide relevant elements for the debate on public policy and managerial implications for the insertion of bioenergy within national energy matrices in general. Hence, it seems pertinent to address some issues related to the goals and guidelines of the National Biodiesel Production and Usage Program (PNPB), such as: to what extent

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has the PNPB succeeded in diversifying the feedstocks used for biodiesel production?; to what extent has the program succeeded in improving the participation of family-based farming in the production of feedstocks?; to what extent has the program succeeded in encouraging the production of biodiesel in the poorest regions of Brazil?; how effective is the government's subsidy of biodiesel?; is biodiesel production cost-effective?. Therefore, the aim of the present research is to characterize and analyze the emergence of the biodiesel industry, and assess the extent to which the goals established by the PNPB have been achieved.

In addition to this introductory section, the second section of the paper presents the method and procedures used to collect and analyze data. In the third section, the policies and guidelines of the PNPB are highlighted. In the fourth section, there is a description of the biodiesel chain. The fifth section discusses the accomplishments of the PNPB in the light of its goals. Finally, the conclusions summarize the study.

2. Policies and drivers to stimulate the production and use of biodiesel

To encourage the production and use of biodiesel, the Brazilian government has built a framework based on legislation, plans and programs for the development and the introduction of this fuel in the Brazilian energy matrix. The introduction of biodiesel assumed strategic importance for national development based on the following pillars: reduction of energy imports, development and job creation in rural areas and a reduced environmental impact due to the use of a renewable fuel.

In December 2004, the Federal Government established the PNPB – National Biodiesel Production and Usage Program, which establishes the regulatory framework through which biodiesel has been incorporated into the Brazilian energy matrix and that is currently driving the structuring of the sector. Its main objectives are (MME, 2011b):

- Implement a sustainable program, promoting social inclusion (Strengthen family-based agriculture in biodiesel production);
- Ensure competitive prices, quality and supply;
- Produce biodiesel from different feedstocks and in different regions of the country.

Managing the PNPB is the responsibility of the Biodiesel Inter-Ministerial Executive Committee (*Comissão Executiva Interministerial do Biodiesel* – CEIB), which was established in order to implement actions intended to promote the production and use of biodiesel as an alternative energy source and the program Management Group, coordinated by the Ministry of Mines and Energy. Each of these agents has specific functions related to ensuring the implementation and monitoring of the program, as well as the implementation of actions related to compliance with the programs guidelines and strategies (MME, 2011b). The CEIB also has the task of proposing any regulatory acts that may be necessary to implement the program and analyzing, evaluating and proposing other recommendations and actions, guidelines and policies.

One of the first actions resulting from the PNPB was the establishment of minimum percentages of biodiesel to be mixed with diesel, via the Act 11.097/2005, which ensured the inclusion of biodiesel in the Brazilian energy matrix. By sanctioning this law, the government acted not only in relation to ensuring the supply of biodiesel to the consumer market, but also established the National Agency of Petroleum, Natural Gas and Biofuels – ANP as a regulator of the biodiesel industry, which would be responsible for overseeing the activities of the members of the industry, ensuring product quality and compatible prices for biodiesel.

The PNPB also quickly generated a set of policies and guidelines, developed and implemented by various ministries (such as those of Finance, of Transport, of Agriculture, Livestock and Supply, of Mines and Energy, of Science and Technology, of the Environment and of Rural Development) to support the strategic guidelines defined in this program. Table 1 presents the main policies designed to encourage biodiesel that have been developed and implemented by the Brazilian Ministries.

As shown in Table 1, these policies include tax incentives, regulations, the provision of technical assistance (Becker et al., 2011), as well as social inclusion policies and credit incentives. Policies designed to promote social inclusion are common in Brazil, and are intended to direct efforts to minimize and gradually bridge the socioeconomic gaps that permeate the Brazilian social structure.

From the elements contained in Table 1, it can be seen that the PNPB has been conceived, structured and managed so as to enable the coordination and integration between policies aimed at different actors involved in the biodiesel supply chain.

As for the basic guiding principles of the PNPB to promote social inclusion, regional development and the diversification of raw materials, the Program has resources for research, development and innovation (RD&I) throughout the production chain, ranging from the agricultural phase to the industrial production processes and consumption (quality) including co-products and storage.

Among the many government initiatives intended to stimulate the biodiesel production chain, the role of the Social Fuel Seal, which is awarded by the MDA, in promoting social inclusion and diversification of the regions producing biodiesel is of particular note. The Social Fuel Seal is a certificate awarded to biodiesel producers that: (a) acquire minimum percentage of feedstocks from family farmers, (b) enter into contracts with family farmers establishing deadlines and conditions of delivery of feedstocks, and (c) provide technical assistance to the farmers.

The Social Fuel Seal offers tax benefits to biodiesel production plants on the condition that part of the feedstocks (oil seeds) comes from family-based farms thus encourage their greater participation in the biodiesel production chain. The percentage of the reduction of federal taxes is dependent on the region where the plant is located and the type of feedstock it acquires from the family farms. For example: (a) intensive farming in the North, Northeast, and Semi-arid regions (castor bean and palm) receives a 30.5% reduction; (b) family-based farming in all regions (any feedstock) receives a 68% reduction; and (c) family-based farming in the North, Northeast, and semi-arid regions receives 100% reduction.

3. The biodiesel chain in Brazil

The Brazilian biodiesel supply chain is comprised of three basic and integrated processes, they are: (1) supply; (2) production; and (3) distribution. These processes provide the basic framework for supplying and converting feedstocks into biodiesel and distributing the final product. Although these processes are common to any supply chain, the biodiesel supply chain in Brazil presents some particularities. It is largely driven by government initiatives and controls intended to achieve social goals such as the insertion of family-based farming in the supply chain and job creation in poor regions of the country. Several government regulatory institutions directly intervene in the way the economic agents conduct business in the supply chain.

Table 1
Policies, ministries, actions and mechanisms in the PNPB intended to stimulate the production and use of biodiesel.
Source: MCT (2011), MDA/SAF (2011a), MAPA (2011a, 2011b), MME (2011b).

Policy	Ministry responsible	Aim/action	Beneficiary	Mechanisms	Policy type: tax incentive; regulatory; R&D; social inclusion
PNPB	**Home office** coordinates the PNPB **MME** – **c**oordinates the PNPB management group	1. Implement a sustainable program, promoting social inclusion. (To strengthen family-based farming in biodiesel production.) 2. Ensure competitive prices, quality and supply. 3. Produce biodiesel from different oilseed sources and feedstocks in different regions	All agencies involved in the production and marketing of biodiesel	Agricultural credit, tax benefits, regulation of the biodiesel trade, lines of credit.	Regulatory tax incentive R&D social inclusion
Social Fuel Seal	**MDA**	Granted to biodiesel producers that promote social inclusion through job and income generation for family farmers, as well as ensuring that they receive technical assistance and training, plus a bonus based on the value of the product traded.	Biodiesel producers, family farmers, cooperatives	Federal tax reduction coefficients and better financing for the processing plants, access to technical assistance, training and increased per-sack prices for family farmers.	Tax incentive R&D social inclusion credit incentive
PRONAF – National Program to Strengthen Family Farming	**MDA**	Funds individual and group projects that generate income for family farmers and agrarian reform settlers, through specific lines of credit.	Family farmers	Lines of targeted funds through financial institutions.	Credit incentive
Feedstock Zoning Plan	**MDA and MAPA**	Agricultural zoning based on the existence of edaphoclimatic and technological-base aptitude of the crops in the different states.	Family farmers	Agricultural zoning	R&D
Sectoral Chamber of Feedstock and Biodiesel Production Chain	**MAPA**	Acts as a consultative forum to identify opportunities for the development of the productive chain of soybeans and other oilseeds, linking public and private agents, defining priority actions of common interest, aimed at producing biodiesel.	Farmers	Promotes research	R&D
Sustainable Palm Oil Production Program	**MAPA**	Adequacy of credit lines, the search for technological mastery through investment in research, development and innovation, and to enhance the dialogue with the productive sector through the sectorial chambers.	Farmers	Proposition lines of financing, investment in research and development	R&D
Biodiesel Technological Development Program	**MCT**	Supports research and scientific and technological development and innovation applied to the use and production of biodiesel by means of the Brazilian Biodiesel Technology Network (*Rede Brasileira de Tecnologia de Biodiesel* – RBTB) in six basic lines: (1) tests vehicles and engines, (2) technology for processing plants, (3) agriculture, (4) waste and by-products, (5) technology services infrastructure and (6) stability and storage.	Researchers, research and educational institutes.	Public calls for bids, agreements, budget decentralization for federal teaching and research institutes.	R&D

As a consequence of the Brazilian government's strong presence in the biodiesel supply chain, there is a distinction between the flow of the production process and the information flow. The former is basically quite similar to all biodiesel supply chains around the world, following the best production and technological trends developed for the biodiesel. The latter is characterized by the extensive presence of the government, which regulates and controls the production agents and how they interact. The regulatory policies define several important aspects that determine the dynamic behavior of the supply chain, such as the total biodiesel demand, feedstock origin, maximum biodiesel price at the fuel distribution level, and much more. The roles of the governmental and regulatory agents will be discussed in detail in the description of each process.

Fig. 1 illustrates the three main processes described above, characterizing the main agents involved in each one, including those that have a regulatory role, like the National Confederation of Agricultural Workers – CONTAG (from the Portuguese *Confederação Nacional dos Trabalhadores na Agricultura*), the Ministry of Rural Development (*Ministério do Desenvolvimento Agrário* – MDA and the ANP, as well as the physical and informational flows through the Brazilian biodiesel supply chain. It should be noted that the rules, laws, and regulations, represented by the information flow, make the Brazilian supply chain quite complex.

3.1. *The supplying link*

The climatic diversity and large territorial extension of Brazil permit the production of a wide range of biodiesel feedstocks. However, soybean oil is the predominant feedstock for biodiesel production, with alternatives having a very low share. For example, in 2011, in the period until August, soybean oil met 84.23% of the demand, beef tallow 12%, cottonseed oil 1.94% and other feedstocks 1.96% (ANP, 2011a).

A feature of agricultural production in Brazil is the strong presence of two distinct production systems, family-based farming and large-scale farming. The former has been the focus of government attention in the biodiesel chain. The participation of family farming in the biodiesel production chain is guaranteed because in the auctions for the sale of biodiesel part of the volume to be sold by the production plants is reserved for those that hold the Social Fuel Seal. According to the rules of the Seal, 30% of the feedstocks used in the production of biodiesel in the processing plants located in the Northeast, Southeast and Southern Brazil must come from family farms and 15% for those located in North and Center-West.

It is worth noting that with the Social Fuel Seal, biodiesel production plants are expected to have their contracts with family farms in accordance with the regulations of the Seal, regardless of whether the contracts are directly with the farmer or through a farmers' cooperative. During the contractual negotiations between the plants and family farmers, the presence is required of at least one representative of a small farmer association, whether a trade union or one affiliated to CONTAG. The MDA has delegated CONTAG to negotiate and supervise the trade in feedstock between the biodiesel production plants and family farmers.

In relation to the Social Fuel Seal the concept of family farming is defined by Law No. 11326 of July 24th, 2006. A family farm is one in which the farm activities are predominantly preformed by members of the family occupying the farmland, with an area of no more than 4 tax modules (one tax module corresponds to an area from 50 to 100 ha in the Northeast, 15 to 90 ha in the Centre-West, 5 to 110 ha in the North, 50 to 40 ha in the South, and 5 to 70 ha in the Southeast,) and in which the family income originates predominantly from activities related to its rural setting (IBGE, 2006a).

The Cooperative is another actor in the supply of feedstocks for biodiesel production. Within the biodiesel chain they act as a mediator between the production plants and the family farmers, ensuring that the latter are more firmly integrated in the chain, providing more bargaining power when dealing with the plants, with regard to the price paid for oilseeds, as well as reducing their fragility when defining prices both during the purchase of inputs and the sale of their produce (Neto, 2001).

3.2. *Biodiesel production*

The Federal Government sets the national demand for biodiesel by specifying the mandatory percentage of biodiesel to be

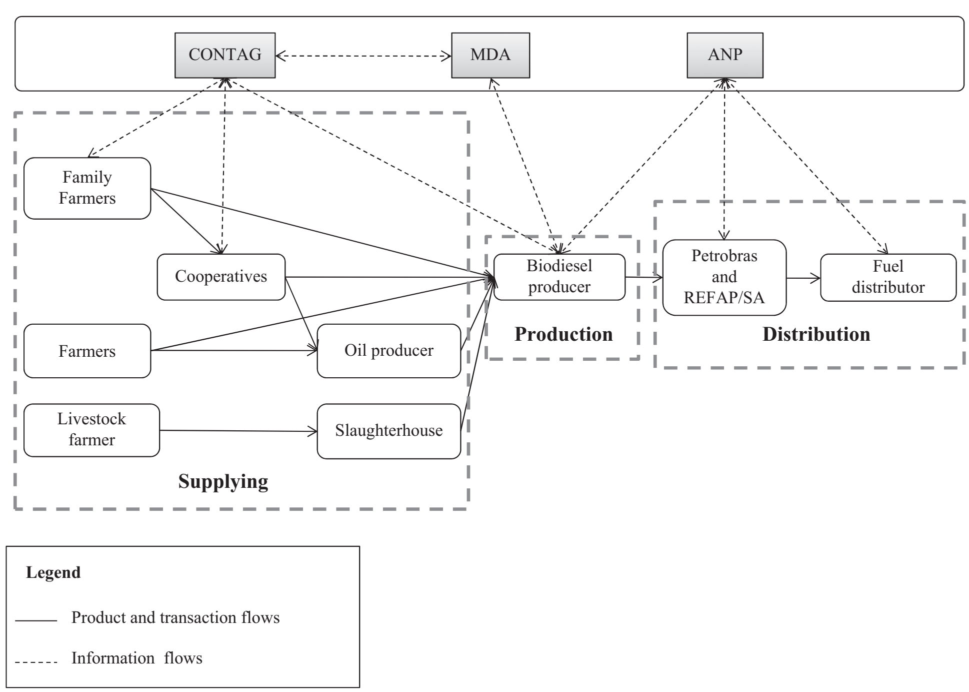


Fig. 1. Biodiesel supply chain in Brazil.

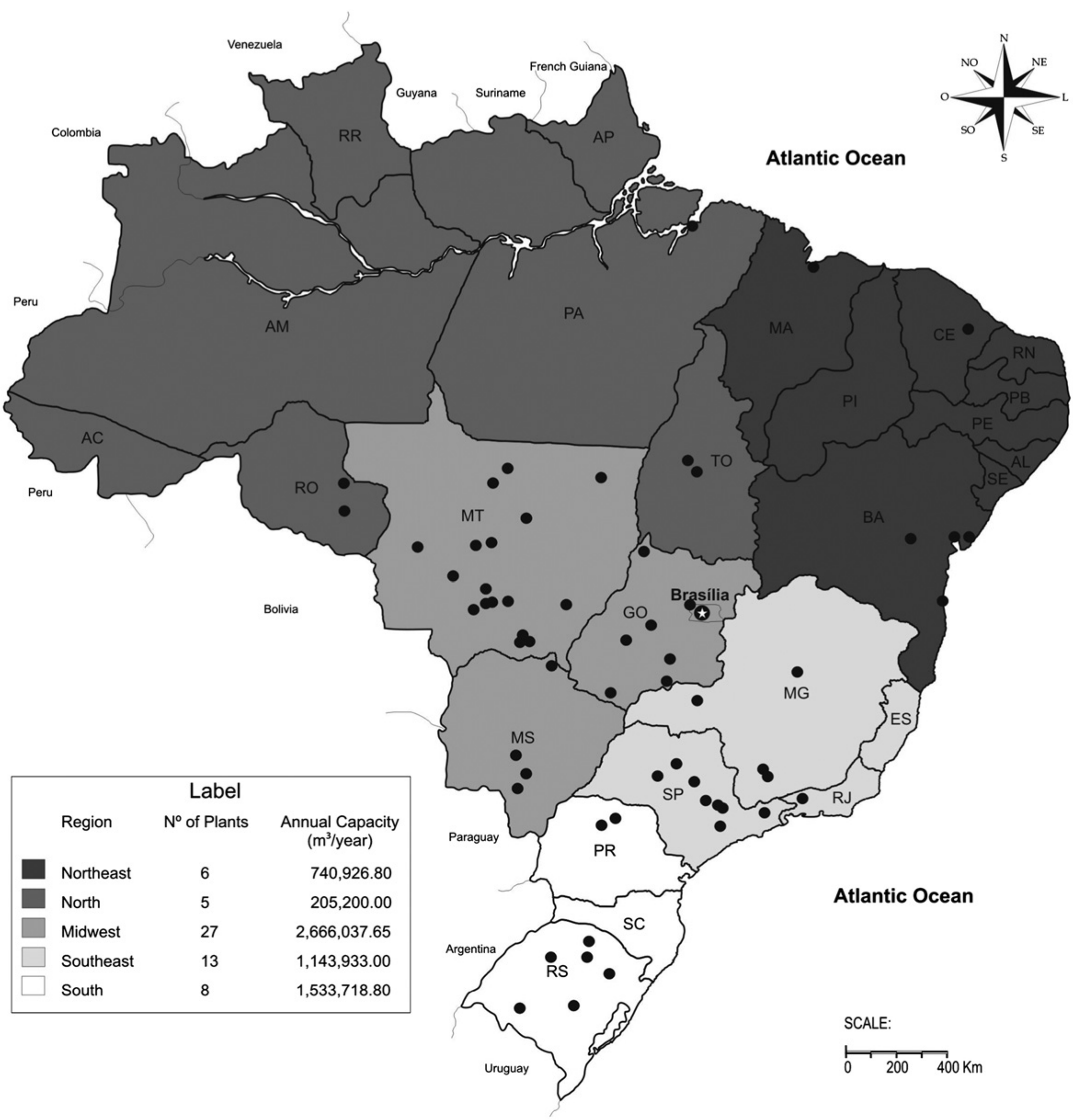
mixed with petroleum-based diesel in the country. As from January 2005 (Law 11.097/05), refiners and distributors were allowed to add up to 2% biodiesel to diesel (B2). In 2008, that percentage became mandatory due to the rapid response from the supply side. While the PNPB established the percentage should increase to 5% (B5) as from the end of 2013, due to the rapid expansion of the supply, the 5% (B5) mandatory percentage was set in 2010, three years ahead of schedule. Even so, the productive capacity remains larger than the demand for biodiesel.

The incentives offered by the government to the companies interested in producing biodiesel have led to investments in the sector in the different Brazilian regions. Many of the current biodiesel plants were previously established players in the market as producers of vegetable oil, and have used the existing structure to enter into the biodiesel business. The less vertical plants, which do not include a crushing plant within their structure, choose to rent a crushing plant to process the feedstocks or buy oil from the crushing companies (Santos, 2009).

Biodiesel production in Brazil has grown significantly in recent years, went from 736 m^3 in 2005 to more than 2530,000 m^3 biodiesel in the year 2011, and even with the increased demand there is still a significant amount of idle capacity, around 59.7%. According to the ANP (2011b), in November 2011 there were 59 plants authorized to operate and sell their product, giving a total capacity of licensed production around 6.2 million m^3 per year (around 500,000 m^3/month).

Of those plants authorized to operate and sell 79% pertains to companies that have the Social Fuel Seal (MME, 2011c). As shown in Map 1, the production plants are distributed throughout the national territory. The Central-West region has the largest number of plants and the largest installed capacity. The South and Southeast regions are the 2nd and 3rd largest regions, respectively. The North and Northeast regions have the least plants and the smallest installed capacity, although they receive special attention from the PNPB with actions and measures designed to benefit them by promoting the diversification of biodiesel production among the regions.

Six years after the implementation of the PNPB, two main modes of organizing biodiesel production in Brazil can be seen to exist (Padula et al., 2007). Business type-1 is characterized by



Map 1. Location of the authorized biodiesel production plants in operation.
Source: Elaborated based on data from the National Petroleum, Gas and Biofuels Agency – ANP (2011b).

large-scale production plants, represented by large soy oil and biodiesel manufacturers. By contrast, Business type-2 involves small production volumes and local coverage. As shown by Santos and Padula (2011), in 2010 approximately 66.9% of the biodiesel came from large plants that can be characterized as Business type 1. It should be noted that this volume was produced by 8 companies from a total of 47 plants in operation at that time (Santos and Padula, 2011).

3.3. Biodiesel distribution

The biodiesel is traded through two auction processes. In the first, held by the ANP, the biodiesel production plants offer the B100 to refineries that produce diesel, thus concentrating the sales in only two buyers, Petrobras and REFAP – Alberto Pasqualini Refinery (a subsidiary of Petrobras). In the second, referred to as a reverse auction, Petrobras and REFAP sell the B100 to distributors.

The B100 biodiesel produced by processing plants is distributed directly to the distributors, such as Ipiranga, Chevron, Cosan, Shell, Total and Petrobras. The distributors are responsible for blending and subsequently distributing the B5 diesel to service stations that serve the end customer.

The ANP is responsible for initiating, organizing and conducting the auctions of the B100 biodiesel produced by the production plants to the refineries, this being accomplished by means of an electronic auction, using a Dutch auction type. The announcement of the electronic auction published by the ANP contains the maximum reference price and the volume of each batch to be auctioned and the criteria and characteristics of the eligible buyers (fuel refineries) and bidders (biodiesel producers). The maximum reference price, established by the ANP, is mainly based on the manufacturing costs, considering several different feedstocks, production methods, and regional peculiarities, financial costs, and taxes. After accreditation, the day is set for the auctions and the producers make their bids, with a discount on the maximum price, and whoever offers the lowest price wins. The behavior of the auctioneers has been typical of a Dutch auction. The existence of spare capacity in biodiesel plants makes the competition between biodiesel producers higher, decreasing the winning price. Based on the data of the 22 auctions performed, it is possible to conclude that the average final winning price has been slightly inferior to the maximum price set by ANP, with an average gap of 7.46%. The maximum gap recorded was of around 25.21% in auction 19 that occurred in September, 2010 (ANP, 2011c).

The biodiesel remains in the control of the plants until the distributor who acquires the biodiesel at re-auction withdraws it, or receives the referred amount from the plant itself. The shipping mode is determined in the rules of the auction at which the plant sold its biodiesel.

In the auctions held by Petrobras/REFAP to sell the B100 the distributors can acquire a volume of biodiesel which is proportional to their share of the domestic market for diesel oil. The auctions take place within consumption centers and the minimum values are defined regionally. The distributors are responsible for making the final biofuel available to the consumers.

Until the 22nd auction, the maximum price was set based on an estimate of the cost of producing the biodiesel without considering the logistics costs involved, which benefited the processing plants located further from the centers of consumption and distribution. As a result, the existence of a single reference price has begun to be challenged by the biodiesel producers. In an attempt to adjust this failure in the formation of the maximum price the government has implemented, as from the 23rd auction, the Logistics Adjustment Factor (FAL) in the auctions, which is the value that must be added at the time of the bids made by the production plants, considering their location.

4. Assessing the achievements of the PNPB

This section deals with the main results obtained by the PNPB in light of the objectives established for the program. The points discussed are: the diversification of feedstocks, production of biodiesel in different Brazilian regions, the inclusion of family farming in biodiesel production, the economics of biodiesel production, and the sustainability (environmental, economic and social) of production of biodiesel.

4.1. Diversification of the feedstocks used in biodiesel production

Brazil is a major producer of oilseeds, cattle and poultry and so is able to meet the demand arising from the production of biodiesel with many different types of oilseeds and animal fat. In terms of the production volumes of oilseeds, soy is the leader with peanut a distant second. The production of other oilseeds (cotton, castor, rapeseed and sunflower) has not yet been established on a sufficiently large scale (MAPA, 2011a, 2011b).

Regarding animal fat, beef tallow is produced in significant and regular volumes due to the size of the Brazilian cattle herd of 202 million animals in 2008 (IBGE, 2011), which explains why beef tallow has become the second most used raw material in the production of biodiesel as Brazil from 2008 (Table 2).

Based on data obtained from studies conducted by different government ministries, research organizations and universities on the implementation of the PNPB it was possible to prepare Table 2 which shows the strengths, weaknesses and challenges involved in the use of the different feedstocks and raw materials used in biodiesel production (swc analysis).

Table 2 shows that those feedstocks and raw materials that have structured and organized supply chain (soybean soil and beef tallow) have taken the lead in the production of biodiesel. On the other hand, those oilseeds that do not have structured and organized supply chains (castor, rapeseed, sunflower, jatropha), despite having several strengths and being supported by considerable incentives and public policy have yet to overcome the challenges faced in their different stages of production: agriculture, industrialization and distribution.

4.2. Biodiesel production in the Brazilian regions

Analysis of biodiesel production helps identify a certain concentration of production in some regions, as shown below in Table 3.

In 2010, the South, Southeast and Midwest regions were responsible for approximately 88% of the biodiesel produced in Brazil. The production of biodiesel from soybean oil is concentrated in the South and Midwest. It is worth noting that these two regions are also responsible for approximately 85% of soy production in Brazil (IBGE, 2006b). In the Southeast biodiesel is mainly produced from beef tallow. The Southeast Region is responsible for approximately 80% of total production capacity of biodiesel from beef tallow (Brianezi, 2009), has 18% of the national cattle herd, and concentrates large abattoirs and meat processing plants and chillers, many of which are accredited to produce and sell biodiesel.

The North and Northeast regions were responsible for the production of only 12% of biodiesel produced in 2010, mostly produced from soybean oil. Thus, it is clear that the objective of diversifying the regions producing biodiesel is compromised by the difficulty of establishing and expanding the cultivation of

Table 2
Share of feedstocks/raw materials used in biodiesel production from October/2008 to August/2011 and swc analysis.
Source: Barreto (2007), Brianezi (2009), Matsumura and Yokohama (2005), Durães (2011), Duarte (2011), Freitas (2011), Gomide (2011), Gomes de Castro et al. (2011), Mesquita (2011a), Mesquita (2011b), Rathmann et al. (2011), Tsai (2009).

Feedstock/ raw material	%*	Region	Strengths	Weaknesses	Challenges
Soybean oil	80.9	Midwest, south	Brazil is the 2nd largest producer and 2nd largest exporter of oil;	Low oil content in the grain (18% a 20%);	Research and development of a variety with higher oil content.
			The production chain is well organized and consolidated;	Cost of producing oil is higher than that of mineral diesel;	
			The biodiesel processing is mainly carried out by the large crushing companies;	Expansion in production takes place through expansion of planted area;	
			The oil used for biodiesel does not compete with food production.	Low rate of reduction of greenhouse effect.	
Beef tallow	14.2	Southeast, midwest	Brazil has a large cattle herd;	Does not benefit from tax incentives and exemptions from the Social Fuel Stamp and;	Include family cattle raising in the Social Fuel Seal
			Large beef processing capacity in the different Brazilian regions;	Technical limitation: instability linked to storage temperature;	Meat processing plants need to track family raised cattle supply chain.
			Vertical production chain (meat processing plants also produce biodiesel);		
			Production costs lower than is several oilseeds.		
Rapeseed oil	0	South	Oil is excellent quality for biodiesel;	Brazil is an importer of rapeseed;	Encourage the expansion of rapeseed production in the different Brazilian regions;
			High oil content in the grain (38% to 40%);	Brazil is not a traditional grower;	Research the development of highly productive and pest resistant varieties;
			Crop adapted to a variety of climates and soils;	It is a secondary winter crop;	
			Does not compete with food, since it produces a rich bran suitable for human and animal consumption;	Low agricultural productivity.	
			High rates of reduction in greenhouse effect;		
Palm oil	0.1	North, northeast	Potentially high agricultural productive level;	Low oil content per grain (20% to 22%);	Concession of additional tax incentives and subsidies in the Social Fuel Seal;
			Perennial plant with up to 25 years of useful life;	Lack of tradition of production in Brazil;	Structuring and organizing the production chain;
			Does not compete with for land use for food production;	Brazilian production below the world average;	Providing the farmers with technical assistance;
			Expanded production can be achieved through greater productivity;	Produced largely in the Legal Amazon, with restriction to the expansion of the agricultural area;	Improve production systems and increase productivity to international levels.
			High rates of reduction of greenhouse effect.	Brazil is a net importer of palm oil.	
Castor oil	0	Northeast	High levels of oil in the grain (45% to 55%);	Low production in Brazil;	Structuring and organizing the production chain (agriculture, processing and distribution of the oil;
			Adapted to the Brazilian northeast	Low levels of agricultural productivity;	Providing the farmers with technical assistance;
			Growing and harvesting system adapted to family farming;	Predominantly under-capitalized family-based farming with low level technology;	Structuring cooperatives for the crop and production of the oil.
			Few agricultural inputs required;	Disorganized production chain;	
			Crop lends itself to cooperative forms of production;	Oil not recommended for use in biodiesel production;	
			High levels of reduction of greenhouse effect.	Brazil is a net importer of castor oil.	
Sunflower	0	South, southeast, northeast	High oil content in the grain (45%);	Brazil has no tradition of growing the crop;	Encouraging and expanding production;
			Bran has high levels of proteins for human and animal consumption;	Disjointed production chain;	Providing the farmers with technical assistance;
			Suited for growing in throughout Brazil;	Higher production costs in comparison with other oilseeds;	Raising the productivity levels;
			High levels of reduction of the greenhouse effect.	Brazil is a net importer of sunflower oil.	Structuring and organizing the production chain.
Jatropha	0	Northeast, north	High agricultural productivity per area;	Brazil has no tradition of growing the crop;	Investments in genetic research;
			Perennial plant;	Early stages of plant domestication;	Providing the farmers with technical assistance;
			Does not compete with other food crops;	Disappointing early production results;	Improving tem production systems;
			Can be planted in degraded areas;	Requires irrigation and fertilizer in semi-arid regions;	Requires 3 to 5 years to analyze tem life cycle;
			Excellent quality oil for biofuels	Not recommended for growing in small properties;	Structuring and organizing the production chain

* % of the average share in the biodiesel produced between October 2008 and August (ANP, 2011a).

Table 3
Production of biodiesel in different Brazilian regions from 2005 to 2011 (in m^3).
Source: Elaborated based on data from the ANP (2011d).

	2005	2006	2007	2008	2009	2010	2011*
South	26	100	42,708	313,350	477,871	675,668	650,588
Southeast	44	21,562	37,023	185,594	284,774	423,123	245,549
Midwest	0	10,121	125,808	526,287	640,077	1017,986	665,341
Northeast	156	34,798	172,200	125,910	163,905	186,297	99,845
North	510	2,421	26,589	15,987	41,821	93,881	66,871
Total	736	69,002	404,329	1167,128	1608,448	2396,955	1728,194

* Until August 2011

Table 4
Evolution of the purchase of feedstocks from family farmers in Brazil by companies holding the Social Fuel Seal between 2005 and 2010.
Source: Elaborated based on MDA/SAF (2011b).

	2005	2006	2007	2008	2009	2010
Number of establishments	16	41	37	28	51	100
Values acquired (in Million Reais*)	0	68.57	117.50	276.54	677.34	1,058.70

* (R$1.00 = US$0.55).

castor, palm, jatropha and sunflower in North and Northeast Brazil, as shown in Table 2.

4.3. The participation of family farming in biodiesel production

One can see an evolution in terms of the participation of family farming in the PNPB, as shown in Table 4. The value of total purchases of feedstocks originating from family farming in 2010 (R$1.058 billion) represents approximately 26% of the amount of feedstocks purchased by companies holding the Social Fuel Seal in that year (R$4.043 billion). This trend needs to be evaluated with some caveats, since it includes acquisitions of biodiesel by companies that sell the product in ANP auctions in which a share of the total volume to be sold at auction is reserved for companies holding the Social Fuel Seal, under the rules of which such companies are obliged to purchase feedstocks from family farmers.

Soybean was the oilseed that most contributed to the acquisition values of family farming, while the participation of alternative oilseeds (rapeseed, sesame, palm, sunflower, peanut) was not significant in 2010 with a value of R$ 57.28 million, compared to the total value of purchases acquired from family farming of approximately R$ 1.058 billion (MDA/SAF, 2011b).

As for the distribution of the participation of family farming by regions in Brazil, the South stands with approximately 52% of the establishments and 68% of the purchase value. The strong participation of family farmers in this region is due to the strong presence the farmers organized into cooperatives and the ability of large soybean crushing and soybean oil refiners in the region to organize supply chains (MDA/SAF, 2011b).

The Midwest region, despite having a less significant number of family farms, 3.3% of all such establishments participating in the PNPB, has a large share of value of the purchases of feedstocks, 23% of the total (MDA/SAF, 2011b). This situation has come about due to the fact that in this region the regulations of Social Fuel Seal require that a smaller share of feedstocks used in the production of biodiesel come from the family farming, only 15%, and also due to the definition of "tax module" which allows this region to include farms with larger average areas.

Regarding the Northeast, although the region has a significant percentage of the family farms (41.2%), this is not reflected in the value of the acquisitions from family farming in 2010 (5%), (MDA/SAF, 2011b). One factor that seems to contribute to this situation is that soybean production is less significant in the small family farms in this region (MAPA, 2006).

The North and Southeast show a modest share of the supply of feedstocks obtained from family farmers by companies holding the Social Fuel Seal. While the Southeast region produces a significant volume of biodiesel, 14% of Brazilian production, the main feedstock is beef tallow, which does not benefit from the Social Fuel Seal incentives.

4.4. The economic aspects of biodiesel production

The production costs of biodiesel are strongly influenced by the raw materials used, the scale of the plants and the tax rates. Thus, these costs may be highly variability due to diversity of raw materials (soybean, rapeseed, sunflower, cotton, animal fat, etc.), the regions where the biodiesel is produced (different rates of tax between regions) and the diversity of scales of production in different regions.

Since biodiesel production on an industrial scale has only recently been introduced, consolidated data are not yet available on production costs and the value of specific tax exemptions for biodiesel production in the different Brazilian regions and for each of the different feedstocks and raw materials used (soybean, rapeseed, cotton, sunflower, animal fats, etc.).

The ABIOVE (the Brazilian Vegetable Oil Industry Association), considering the international prices of the different vegetable oils and petroleum, the production capacities of the plants and the tax structure in Brazil, estimate a cost of US$0.73/liter and a final price of US$1.00/liter of biodiesel from soybean oil, without taxation, with the reference values of 2005 (Biodieselbr, 2011). This pre-tax price for biodiesel is similar to the price the diesel produced from petroleum, after tax. Thus, biodiesel from soybean oil only becomes economically competitive with conventional diesel fuel if a system of tariff reduction is adopted. The tax waiver is close to US$0.22/liter, referring to the amount of taxation on mineral diesel. Studies and simulations performed by Barros, Alves and Osaki (2008) also suggest that biodiesel is approximately 20% more expensive than fossil diesel.

It should be noted that the preliminary evidence and studies indicate that the tax exemptions and fiscal incentives have been focused on the processing and industrialization of biodiesel (Rathmann and Padula, 2011; Ribeiro de Matos, 2011) and that the family farmer gains a small additional premium for the sack of oilseed sold for the production of biodiesel.

In addition to the exemptions and incentives offered by the Social Fuel Seal during the production of biodiesel, some data and results on the marketing structure of biodiesel seem to reveal the existence of subsidies also at this stage of the production chain. Fig. 2 shows that the purchase prices of biodiesel in the ANP auctions have been consistently higher than the price of petroleum-based diesel produced by the refineries. The difference in the prices paid to companies operating biodiesel processing plants shows a kind of "trade subsidy" applied in this economic sector.

4.5. Elements of sustainability of biodiesel production

Evaluating the sustainability of the production and use of bioenergy is an ongoing issue. Some organizations such as the FAO (Food and Agriculture Organization of the United Nations) and the Global Bioenergy Partnership (GBEP) have launched initiatives intended to validate tools and approaches used to assess the sustainability of bioenergy systems, one of these initiatives is the biofuels sustainability scorecard (Ismail and Rossi, 2010). Other approaches seek to assess the indirect impacts of bioenergy production (Dehue, 2010) or the impact of changes in land use and the degree to which the production and consumption of bioenergy mitigate climate change (Berndes, 2011; Panichelli and Gnansounou, 2008; Dehue, 2010; Rathmann et al., 2011) or the issue of food security and bioenergy production (FAO, 2008; Rathmann et al., 2010).

A study conducted by Embrapa looked at the elements and aspects of sustainability, and assesses them on a scale from 1 (low competitiveness or sustainability) to 4 (high competitiveness or sustainability) (Gomes de Castro et al., 2011). Based on this study together with the elements identified by other authors (Beltrão, 2011; Amaral, 2011; MDA/SAF, 2011B; Rathmann et al., 2011), Table 5 presents the elements of sustainability of some oilseeds involved in the production of biodiesel.

While on the one hand, the production chain of biodiesel from soybeans shows lower rates of production and environmental sustainability, on the other it has a high impact on the HDI in the municipalities where it is cultivated as well as a positive energy balance (Rathmann et al., 2011). The production chain of biodiesel from palm oil scores highly in terms of productivity issues and low scores in relation to environmental sustainability, mainly because most of the production is in the Legal Amazon region, and the impact on the HDI in the municipalities where the crop is cultivated. Castor, sunflower and rapeseed appear to have great potential for contributing towards the sustainability (environmental, economic and social) of biodiesel production in Brazil.

As for reducing the emissions of greenhouse gas (GHG) and pollutants, biodiesel can reduce such emissions by 57% in relation to fossil diesel (Beltrão, 2011). Projections by the FAO/GBEP (Clini and Muller, 2008) suggest the same path, but it should be pointed out that the literature on the balance of GHG emissions achieved by replacing diesel by biodiesel is divergent.

An indirect impact of the expansion of production and consumption of biofuels that should be signaled is the possible competition for land use: food versus biofuels. The rapid expansion of biofuels production requires the expansion of the production of feedstocks. In a study into competition for land use and food production of liquid biofuels in different regions of the world, Rathmann et al. (2010) found that between 2005 and 2007 the rate of growth in the use of oilseeds for biofuel production was higher than the growth rate of production of these crops. This may signal a shift in the allocation of land use. Although there is controversy about the existence or otherwise of competition for land to grow food or to grow feedstocks for liquid biofuel production, there is already evidence of competition with shifts from pasture and soybean to sugarcane in Brazil and from wheat to corn in the United States. In both cases, these changes in production have led to increases in prices of these feedstocks and increases in the value of arable land, with negative consequences for the cost of food.

More specifically regarding biodiesel in Brazil, although one aim of the PNPB is to diversify feedstocks for biodiesel production,

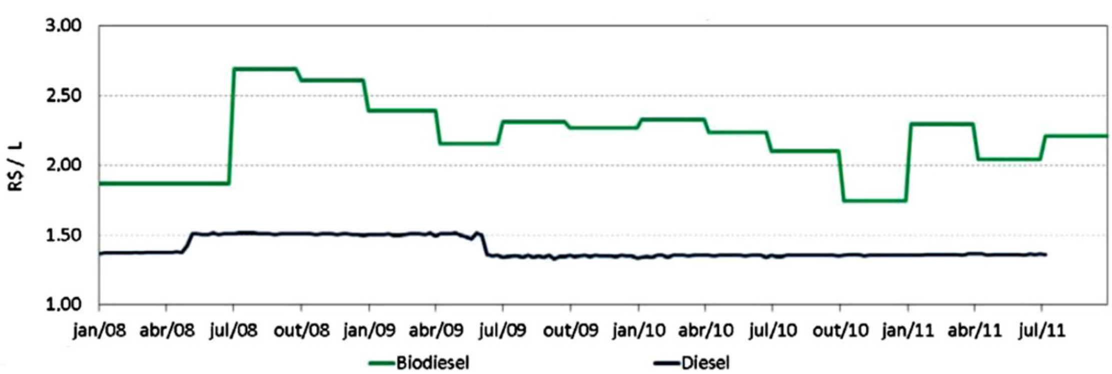


Fig. 2. Evolution of biodiesel auction (average) and petroleum-based diesel prices in the period 2008 to July 2011 in R$ (R$1.00=US $ 0.55).
Source: MME (2011c).

Table 5
Sustainability of producing biodiesel from different oilseeds.
Source: Adapted from Gomes de Castro et al. (2011); Beltrão (2011), Amaral (2011), MDA/SAF (2011a, b), Rathmann et al. (2011).

	Soybean	Castor	Sunflower	Rapeseed	Palm
Rate of oil extraction (% oil in the grain).	2	4	4	4	4
Oil produced per hectare.	3	4	3	3	4
Environmental sustainability of the agricultural systems.	2	3	3	3	3
Impact on tem HDI in the municipalities where the oilseed is grown.	4	4	3	4	2

as yet only soybean has reached the scale of production necessary to meet the demand for biodiesel. However, even soy has its limitations to meet this demand. Studies and simulations on future demand for biodiesel and feedstock (Rathmann et al., 2011) indicate that the limits of the availability of soybeans to produce biodiesel will be reached between the B7 and B10 blends, which will exert pressure to increase the prices of this commodity, further compromising the economic sustainability of biodiesel production. Thus, one way to mitigate the impacts on prices and costs of both feedstocks and biodiesel is the diversification of feedstocks. Greater participation of crops such as rapeseed, sunflower, palm, castor bean, jatropha, and animal fat for biodiesel production would reduce the pressure on soybean prices. To this end, public policies and production practices need to be directed to overcoming the challenges identified in previous sections.

5. Concluding remarks, policies and managerial implications

The biodiesel industry in Brazil is undergoing a process of expansion, to a great extent due to the impact of governmental policies and regulations that are directly related to the demand, production and trade of this biofuel. The construction and implementation of the framework for the National Biodiesel Production and Usage Program (PNPB) have taken place in a coordinated and integrated manner, involving various ministries and governmental bodies.

The results of this research show the impact that the policies, drivers and regulatory framework of the PNPB have had in the structuring, management, maintenance and expansion of the biodiesel chain in Brazil. There is a need to discuss to what extent the National Biodiesel Production and Consumption Program (PNPB) is achieving its goals.

Regarding the goal of including biodiesel within the Brazilian energy matrix, the program can be seen to be responding dynamically and ahead of schedule. In 2010, the B5 blend was already part of the diesel consumed in Brazil. Regarding the use of feedstocks for biodiesel production, soybean oil and beef tallow predominate, with alternative oilseeds obtaining only a minimal share. This is mainly due to the existence in Brazil of a highly consolidated agricultural and industrial production base for soybean and cattle farming.

In relation to the goal of diversifying the feedstock used to produce biodiesel, this goal has not been achieved due to a number of difficulties. The oilseeds that do not have structured and organized supply chains (castor, rapeseed, sunflower, palm, jatropha), despite having several strengths and enjoying considerable incentives and support from public policies, have yet to overcome the challenges faced in their different stages of production: agriculture, industrialization and distribution.

The goal of diversifying the productive base to the poorest regions of Brazil, the Northeast and North, has not been achieved and faces serious difficulties, since, even with incentives provided by the PNPB, castor, palm, jatropha and sunflower have made little headway in these regions.

With respect to social inclusion through the participation of family farming, the aim has been partially achieved. Despite the rapid growth in the participation of family farmers in terms of number of properties, the restrictions on the expansion of the production of alternative oilseeds hamper the inclusion of ''new'' family farm units.

The goal of producing cost-efficient biodiesel is still far from being reached. The economic feasibility of the production and use of biodiesel in Brazil is still strongly supported by tax reductions and subsidies to the production and marketing of biodiesel. Regarding the environmental sustainability of biodiesel, some studies show that the chain of production of biodiesel based on soybean as the feedstock has positive energy balance. The oilseeds castor, sunflower and rapeseed appear to have a great potential for contributing towards the sustainability of biodiesel production in Brazil, since they have both positive economic and environmental impacts.

Although the production of biodiesel has revealed positive externalities, there would seem to a need for debate regarding the ethics of maintaining the National Biodiesel Production and Usage Program (PNPB). Considering that: (a) the production of biodiesel is not cost-effective, (b) the structure of tax reductions and subsidies favors the industrialization stage of biodiesel production, which is the link in the supply chain that is dominated by large processing plants and companies, (c) the diversification of feedstock crops and the insertion of the poorest regions of Brazil has not occurred, and (d) that Brazil has high levels of poverty and social demands in relation to health, education, housing, security, is it ethical to make valuable resources available in the form of tax reductions and subsidies to an industry dominated by ''big business'' while other social needs are underfunded? Would this be an opportunity to redesign the framework of policies, guidelines and regulations of the PNPB so as to benefit the agricultural link (farming family) and the direct generation of ''new'' jobs, by directing to this link in the supply chain a greater share of concession of tax reductions and subsidies?

Some managerial implications emerge from the results of this search. The issues of cost–efficiency in biodiesel production and the reduction or even elimination of the subsidies that currently support the production of bioenergy programs remain key issues in political, technological and managerial agendas (Northoff, 2008; Sorda et al., 2010). The bottlenecks hampering the diversification of feedstocks and expansion of the share of family farming in the biodiesel production chain require that management activities and practices directly related to the structure and organization of production chains (agriculture, industrialization and distribution). Initiatives and investments in rural assistance, financing and infrastructure for the distribution of products, technical assistance, R&D for improved varieties of oilseeds are key factors in raising levels of agricultural productivity and reducing the production costs of biodiesel.

Although several studies on bioenergy policies have been conducted, the questions of territorial extension, productive diversity and income inequality mean the Brazilian experience of biodiesel production has its peculiarities. Despite which, it seems that with due adaptations the results of this research may be used by other countries in the process of formulating policies and decision making when considering the inclusion of bioenergy in the energy matrix.

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References

Amaral, D.F., 2011. Biodiesel no Brasil: conjuntura atual e perspectivas. BiodieselCongress, São Paulo. Available at: 〈www.biodieselcongress.com.br〉.

ANP, 2011a. Agência Nacional de Petróleo, Gás e Biocombustíveis. Boletim Mensal do Biodiesel. Available at: 〈http://www.anp.gov.br/?pg=58491&m=&t1=&t2=&t3=&t4=&ar=&ps=&cachebust=1323956299465〉.

ANP, 2011b. Agência Nacional de Petróleo, Gás e Biocombustíveis. Capacidade Autorizada—biodiesel. Available at: 〈http://www.anp.gov.br/?pg=29048&m=&t1=&t2=&t3=&t4=&ar=&ps=&cachebust=1323956805646〉.

ANP, 2011c. Agência Nacional de Petróleo, Gás e Biocombustíveis. Leilões de biodiesel. Available at: 〈http://www.anp.gov.br/?pg=58713&m=&t1=&t2=&t3=&t4=&ar=&ps=&cachebust=1323957118226〉.

ANP, 2011d. Agência Nacional de Petróleo, Gás e Biocombustíveis. Dados Estatísticos Mensais. Available at 〈http://www.anp.gov.br/?pg=58457&m=&t1=&t2=&t3=&t4=&ar=&ps=&cachebust=1321574012224〉.

Barreto, F., 2007. O potencial agrícola do biodiesel. Available at: 〈www.institutocarbonobrasil.org.br〉.

Barros, G., Alves, L., Osaki, M., 2008. Biofuels, Food Security and Compensatory Subsidies. Available at: 〈www.fao.org〉 and 〈www.cepea.esalq.usp.br〉.

Becker, D.R., Moseley, C., Lee, C., 2011. A supply chain analysis framework for assessing state-level forest biomass utilization policies in the United States. Biomass and Bioenergy 3, 1429–1439.

Beltrão, S., 2011. Além do B5: avaliações necessárias para um aumento com êxito. BiodieselCongress. São Paulo. Available at: 〈www.biodieselcongress.com.br〉.

Berndes, G., 2011. Bioenergy, land use change and climate change mitigation. Available at: 〈http://www.iaebioenergy.com/LibItem.asx?id=6770〉.

Biodieselbr, 2011. Custo de Produção de biodiesel. Available at: 〈www.biodieselbr.com.br/biodiesel/economia/biodiesel-custo-de-produção.htm〉 (acessed 11/22/2011).

Brianezi, T., 2009. O agronegócio domina a cadeia produtiva do biodiesel de gordura animal. Available at: 〈www.reporterbrasil.com.br/agrocombustíveis〉.

Casa Civil, 2005. Casa Civil da Presidência da República do Brasil (Home Office). Lei 11.097/05 de 13 de janeiro de 2005. Available at: 〈http://www.planalto.gov.br/ccivil_03/_ato2004-2006/2005/Lei/L11097.htm〉.

Clini, C., Muller, A., 2008. A Review of the State of Bioenergy Development in G8+5 Countries. FAO/GBEP. Available at: 〈www.fao.org/docrep/010/a1348e/a1348e00.htm〉.

Dehue, B., 2010. Indirect Effects of Biofuels Production. Available at: 〈www.globalbioenergy.org/uploads/media/1105_ECOFYS〉.

Duarte, A., 2011. A Queda do Pinhão-Manso: Passado e Futuro. Available at: 〈www.cnpae.embrapa.br/pasta-NotíciasUd/〉.

Durães, F.O.M., 2011. Diversificação e fontes alternativas de matérias-primas: óleos e biodiesel. Biodiesel Congress. Available at: 〈www.biodieselcongress.com.br〉.

FAO, 2008. Food and Agriculture Organization of the United Nations. Bioenergy Food Security and Sustainability. Available at: 〈www.fao.org/fileadmin/user_upload/foodclimate/HLCdocs/HLC08-inf-3E.pdf〉.

Freitas, R.C., 2011. Selo social: arrumando a casa. Biodieselbr Available at: 〈www.biodieselbr.com.br〉.

Gomes de Castro, A.M., Lima, S.M.V., Silva, J.F.V., 2011. Complexo agroindustrial de biodiesel no Brasil. Editora Embrapa, Brasília (BR), 712 pp.

Gomide, R.B., 2011. Além do B5: avaliações necessárias para aumento com êxito. BiodieselCongress. Available at: 〈www.biodieselcongress.com.br〉.

IBGE, 2006a. Instituto Brasileiro de Geografia e Estatística. Censo Agropecuário da Agricultura Familiar. Available at: 〈http://www.ibge.gov.br/home/estatistica/economia/agropecuaria/censoagro/default.shtmñ.

IBGE (2006b). Instituto Brasileiro de Geografia e Estatística. Censo Agropecuário 2006. Available at: www.ibge.gov.br.

IBGE, 2011. Instituto Brasileiro de Geografia e Estatística. Banco de Dados Agregados. Available at: 〈www.sidra.ibge.gov.br/bda/〉.

Ismail, M., Rossi, A., 2010. A Compilation of Bioenergy Sustainability Initiatives. Available at: 〈www.fao.org〉.

MAPA, 2006. Ministério da Agricultura, da Pecuária e do Abastecimento. Censo Agropecuário. Available at: 〈www.agricultura.gov.br〉.

MAPA, 2011a. Ministério da Agricultura, da Pecuária e do Abastecimento. Câmaras Setoriais e Temáticas. Available at: 〈http://www.agricultura.gov.br/camaras-setoriais-e-tematicas〉.

MAPA, 2011b. Ministério da Agricultura, da Pecuária e do Abastecimento. Plano Agrícola e Pecuário 2011/2012. Available at: 〈http://www.agricultura.gov.br/planoagricola〉.

Matsumoto, N., Sano, D., Elder, M., 2009. Biofuels initiatives in Japan: strategies policies and future potential. Applied Energy 86, 569–575.

Matsumura, Y., Yokohama, S., 2005. Current situation and prospect of biomass utilization in Japan. Biomass and Bioenergy 29 (5), 304–309.

MCT, 2011. Ministerio de Ciência e Tecnologia. Coordenação de Biocombustível. Available at: 〈http://www.mct.gov.br/index.php/content/view/200204.html〉.

MDA/SAF, 2011a. Ministério do Desenvolvimento Agrário/ Secretaria da Agricultura Familiar—Programas. Available at: 〈http://www.mda.gov.br/portal/saf/programas/biodiesel〉.

MDA/SAF, 2011b. Ministério do Desenvolvimento Agrário/ Secretaria da Agricultura Familiar PNPB: inclusão social e desenvolvimento territorial. Available at: 〈http://www.mda.gov.br/portal/saf/arquivos/view/biodisel/arquivos-2011/Biodiesel_Book_final_Low_Completo.pdf〉.

Mesquita, C.V., 2011a. Seminário discute oportunidades e limitaçõe do complexo agroindustrial do biodiesel no Brasil. Available at: 〈www.cnpae.embrapa.br/pastas-NotíciasUd/〉.

Mesquita, C.V., 2011b. Cenário e perspectivas do Programa do Biodiesel foram temas do último dia de seminário na Embrapa. Available at: 〈www.cnpae.embrapa.br/pastas-NotíciasUd/〉.

MME, 2011a. Ministério das Minas e Energia. Brazilian Energy Balance year 2010 – Final Report. Available at: 〈https://ben.epe.gov.br/〉.

MME, 2011b. Ministério das Minas e Energia. Programa Nacional de Produção e Uso de Biodiesel. Available at: 〈http://www.mme.gov.br/programas/biodiesel/menu/programa/objetivos_diretrizes.html〉.

MME, 2011c. Ministério das Minas e Energia. Boletim Mensal dos Biocombustíveis Renováveis no. 45. Available at: 〈http://www.mme.gov.br/spg/menu/publicacoes.html〉.

Neto, B.S., 2001. Agronegócio cooperativo. In: Batalha, M.O. (Ed.), Gestão Agroindustrial. Atlas: São Paulo.

Northoff, E., 2008. Reviewing Biofuels Policies and Subsidies. Available at: 〈http://fao.org/newsroom/en/news/2008/1000928/〉.

Padula, A.D., Santos, O.I.B., Rathmann, R., Dewes, H., Rodrigues, F.C., Borba, R.O., Steinhorst, G.P., 2007. Usage competition between oilseeds and biofuels: impact assessment on the Brazilian food production. In: Proceedings of the 17th Annual World Forum and Symposium of the International Food and Agribusiness Management Association—IFAMA. Parma, Italy. 〈www.ifama.org〉.

Panichelli, L., Gnansounou, E., 2008. Estimating greenhouse gas HG emissions from indirect land use change in biofuels production: concept and exploratory analysis for soybean-based biodiesel production. Journal of Scientific and Industrial Research 67 (November), 1017–1030. Available at: 〈w?w?w?.fao.org〉.

Rathmann, R., Szklo, A., Schaeffer, R., 2010. Land use competition for production of food and liquid biofuels: an analysis of the arguments in the current debate. Renewable Energy 35, 14–22.

Rathmann, R., Padula, A.D., 2011. The decision-making process of the agents belonging to the biodiesel production chain in southern Brazil. Journal of Agricultural Science and Technology, 865–873.

Rathmann, R., Szklo, A., Schaeffer, R., 2011. Targets and results of the Brazilian Biodiesel Incentive Program–has it reached the promised land? Applied Energy, doi:10.1016/j.apenergy.2011.11.021, in press.

Ribeiro de Matos, T., 2011. Aspectos fiscais da cadeia de biodiesel. BiodieselCongress, São Paulo. Available at: 〈www.biodieselcongress.com.br〉.

Santos, M.S., 2009. O Quadro Institucional do Biodiesel d suas Implicações nas Cadeias de Suprimento: Um Estudo de Casos Múltiplos no Estado do Rio Grande Do Sul. Master's Degree Dissertation, Programa de Pós-Gradução em Administração PPGA/UFRGS. Porto Alegre, Brazil, 155 pp.

Santos, M.S., Padula, A.D., 2011. Industrial dynamics of the biodiesel industry in Brazil. In: Proceeding of the 21st Annual World Forum and Symposium of the International Food and Agribusiness Management Association—IFAMA. Frankfurt, Germany. Conference Proceedings (www.ifama.org).

Sorda, G., Banse, M., Kenfert, C., 2010. An overview of biodiesel policies across the world. Energy Policy 38, 6977–6988.

Tsai, W.-T., 2009. Coupling of energy and agricultural policies on promoting the production of biomass energy from energy crops and grasses in Taiwan. Renewable and Sustainable Energy Reviews 13 (6-7), 1495–1503.