Analysis, Design and Implementation of Biodiesel Projects in Brazil

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Abstract

During the oil crisis of the seventies, Brazil has developed a successful program for gasoline substitution by ethanol (Proálcool). Nowadays the biomass accounts for 27% of total national energy consumed in Brazil and the ethanol participates with 40% of the total national fuel consumption of Otto cycle vehicles. In 2004, the National Program for the Production and Use of Biodiesel (Biodiesel Program) was launched. One priority of the Biodiesel Program is the inclusion of family agriculture and smallholders into the production chain. The Federal University of Viçosa (UFV) has developed a software for the analysis of biodiesel projects with the participation of familiy agriculture. Results of production chain analysis and economic indicators calculated by the Biosoft system have allowed identifying the regular supply of oil at competitive prices as the key point to the efficiency of biodiesel production chains. The use of oil cake as feedstock is the leverage point of chain performance. The meal sale can lead to a vegetal oil price reduction, without compromising farmers´ income, since they can be able to set up their own oil extraction plants. Coordination is then the critical element and has the potential to improve the performance of both the biodiesel industry and the animal production chain.

1. Introduction

Since the oil crisis of the 70's, the energy issue is the main subject of economics and geopolitics discussions. The oil reserves are concentrated in a few countries and the forecasts indicate they run out in the next 40 or 50 years. The oil price instability (that reached the highest level of all time in the end of 2007), and insecurity about its regular supply has generated serious conflicts. The environmental impacts of fossil fuels (oil, coal, gas) bring to light another complex matter. The energy supply for a growing world demand imposes huge challenges to national and international energy public policies.

According to the International Energy Agency (IEA), between 1974 and 2004 the world consumption of energy doubled and the share of fossil sources kept constant in around 80% of the total. Crude oil responds to 36% of total energy consumed and short term forecasts indicate no significant changes in the world energy matrix. Despite that, a statement gave by Sheik Yamani' in 1971 underlines the economic and environmental lack of sustainability in world oil dependence: *the Stone Age didn't end for lack of stone, and the oil age will end long before the world runs out of oil*.

Around half of the oil's output is used by the transport sector; and almost 95% of its energy demand is supplied by oil industry. During the oil crisis of the seventies, many countries developed programs for fossil fuel substitution. However, the majority of these programs were not implemented. The Brazilian program for gasoline substitution by ethanol (Proálcool) is a rare exception. Nowadays, renewable energy sources responds for 44% of Brazilian energy matrix, and biomass accounts for 27% of total national energy consumed. Besides that, the Proálcool effectiveness can be seen at the high share (40%) of ethanol in the total national fuel consumption of Otto cycle vehicles.

The Proálcool success is an incentive to the implementation of biofuel programs in developing and developed countries. Biodiesel programs that are being implemented in Brazil and in others countries, should use the Proálcool experience to avoid the same mistakes.

The implementation of biodiesel projects must consider structural and strategic questions related to national energy policies. This information should be systematized and structured through production chain analysis methodologies and project engineering instruments. The objective of this paper is to discuss the experience of the Federal University of Viçosa in the analysis, design and implementation of biodiesel projects in different regions of Brazil.

2. Biofuels in Brazil

2.1 National ethanol program (Proálcool)

The national ethanol program (Proálcool) was lunched in 1973, after the first oil crisis and in 1975 the first ethanol engine was produced. At the end of the seventies the oil represented 46% of Brazilian total imports and its substitution was a key issue for the national economic stability (Morceli, 2007). The use of ethanol as car’s fuel was technically viable and the raw input (sugar cane) was not a bottleneck, considering the availability of arable lands and the national tradition in sugar production.

The Proálcool was based on generous subsidies for automobile and sugar-ethanol industries. The program spectacular development after the second oil crises in 1979 was due to technological advances in ethanol engines, the production chain structuring and efficient ethanol distribution system. At late eighties, almost 90% of all cars produced in Brazil had ethanol engines.

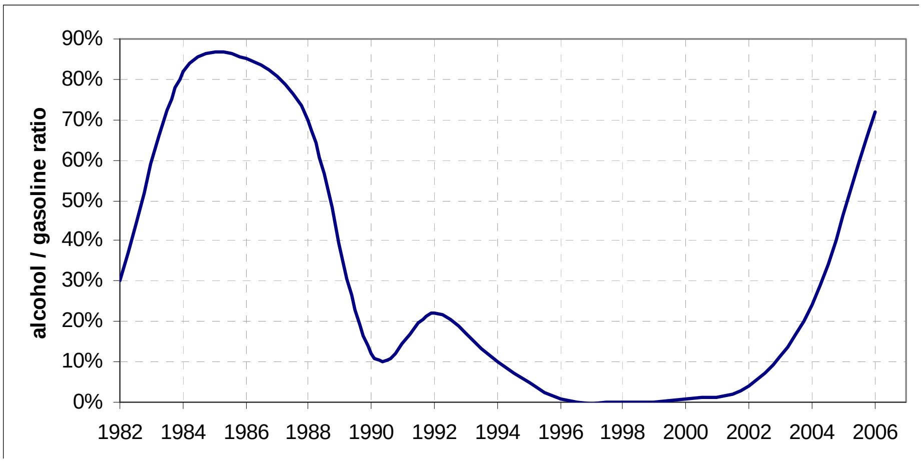
1986 marks the beginning of the Program crisis. The oil price got down, following a significant rise at international sugar price. Without the same governmental support of latest years, the industrial sector prioritized sugar production[1]. Shortage in supply, in all regions, undermined Brazilian consumers’ trust in the Program. In the following years, ethanol engine vehicles sale got down, reaching the insignificant rate of 0.08% of total national vehicles sell in 1997.

Despite the minor ethanol engine car production, Brazilian government did not abandon the gasoline substitution program. The anhydrous alcohol rate mixed in gasoline continuously increased until 25%[2]. This policy kept the market for ethanol, and avoids the ethanol-sugar production chain to dismantle. The crisis had also positive side-effects. Without governmental support, ethanol-sugar industries of southeast region were forced to update and improve their processes related to management, industry and logistic (MAPA, 2007b).

Some initiatives to prompt ethanol engine cars sales were back in 2000. The results were weak until November, 2003, when the Volkswagen Brazil lunched its first “flex fuel” engine. The ignition electronic system of these engines allows any kind of mixture between ethanol and gasoline, including 100% from one of the two fuels. In 2005, these engines represented already half of the national cars sales. In 2007, around 85% of new cars sold had flex fuel engine and

1. Most part of industrial units produces sugar and ethanol in the same plant. The ethanol-sugar rate is regulated by market prices.
2. Nowadays the anhydrous alcohol mixture in gasoline ranges from 20% to 25%. It is used as a market regulatory instrument and is regulated by federal laws.

almost all automobile companies settled in Brazil offered models with this engine (Bourne Jr. 2007).



Source: Morceli, 2007
Figure 1. Sale ratio alcohol/gasoline car

Nowadays, sugar cane production uses 7 millions hectares in Brazil, a relatively small area compared with the 47 millions hectares used for grains production and the 220 millions hectares used by cattle extensive breading. Industrial production of sugar and ethanol are made in 355 industrial plants and sugar cane production in only 45.000 estates[1]. The new 100 plants in construction all over the country will not change the national production structure (MAPA, 2007a; MAPA, 2007b).

Sugar-ethanol industry uses intensive labor during harvest, employing more then 1.5 million rural workers, with a high socio-economic impact, both in regions near industrial plants and in distant ones. A significant part of these workers are migrants from rural poor regions. The salaries are comparatively high, when considering the values obtained in their regions of origin. However, the work conditions are extremely hard. The manual harvest is possible only with plantation burning. Without the burning, cane leafs injures workers and the risk of accidents with snakes and others animals increases significantly. On the other hand, the ashes released increases air contamination and contribute for environmental degradation. The pressure posed by neighboring populations and environmental groups forced the approval of laws at the main producing states that stipulates a schedule of ban on plantation burning. The substitution of manual harvest by mechanical harvest will have significant social consequences.

2.2 National Program for the Production and Use of Biodiesel (Biodiesel Program)

In Brazil, diesel is used exclusively for transport (cargo and passenger), with reduced taxes comparing to gasoline. Despite country auto-sufficiency in oil production, 10% of diesel continues to be imported due to national oil characteristics.

The first initiatives for diesel substitution were proposed after the first oil crisis in the beginning of the seventies. The vegetal oils production for fuel use, the Pro-Óleo, had the same justifications and strategic objectives of the Proálcool (Miragaya, 2005). The program did not have the same support of the Proálcool due to increases in demand and price of edible vegetal oils. All the activities, including industrial and agriculture research did not have continuity.

1. Brazil has 4.5 millon estates (IBGE, 2007).

In Dezember, 2004, Brazilian Government lunched the National Program of Production and Use of Biodiesel (PNPB), establishing obligatory mixtures of biodiesel to diesel, creating market for biodiesel production (Abreu et al., 2007; MAPA, 2007b).

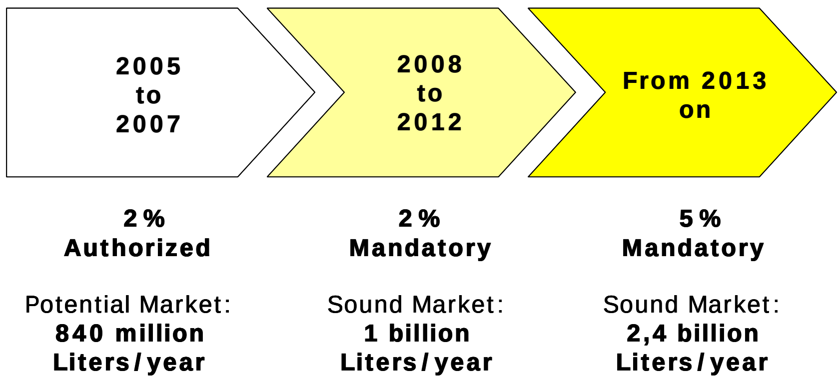


Figure 2. Regulatory framework for the biodiesel / fossil diesel blend

Beyond the objectives of guaranteeing biodiesel supply with quality and competitive prices, the Biodiesel Program has a clear social component. Brazilian government seeks to avoid concentration of industrial and even agriculture production in few companies and estates by seeking economic integration of family agriculture[1]. This integration has its support in a rural loan program and in a social certification program, the “social fuel certificate”.
The social fuel certificate ties fiscal incentives to biodiesel industries to the use of a given part of raw inputs produced by family agriculture. The incentives and the ratio of raw input produced by family agriculture depend on the region and the kind of raw input used. Besides that, the industry must establish contracts with farmers and give the technical assistance necessary (Abreu, 2007).
The diversity of oil crops available and the different oil extraction and biodiesel production technologies allows the implementation of biodiesel plants all over the country. On the other hand, this diversity increases the complexity of production chain and consequently the importance of analyzing the interrelations inside biodiesel production chains.

3. Biodiesel Production Chain

3.1 Analysis of Agro-industrial Production Chains

The analysis of production chain performance is an essential instrument for efficiency increase in agro-industrial systems. The identification of strong and weak points contributes to the formulation of public policies able to eliminate or reduce bottlenecks. The chain analysis allows the identification of challenges and common opportunities, contributing for coordination and collaboration of the production chain´s components (Silva, 2007). This broad and systemic approach is also essential to the feasibility analysis of individual projects, contributing with relevant information for investment decision. According to Staatz (1997) the main task involved in

1. Brazilian government has a clear definition of “family agriculture”: estates that have less then 4 fiscal modules of area (regulated by national legislation); more then half of the labor force is represented by the owner or main land user’s family; and the owner or main land user is in charge of estate management.

the production chain analysis are related with:

1. Describing the current structure of the production chain in terms of activities, actors and ru les involved;
2. Explaining why and how this structure arose;
3. Analyzing the implications of this structure for the current and future economic performance of the chain.

Silva (2007) describes 5 indicators to verify the performance of a production chain: enabling environment; technology; market structure; coordination and firm management.
For each element of a production chain these indicators are evaluated through questionnaires. The sum of the results for all the production chain allows the identification of its weak and strong points. The steps of this approach are presented in the following figure (Silva, 2007).

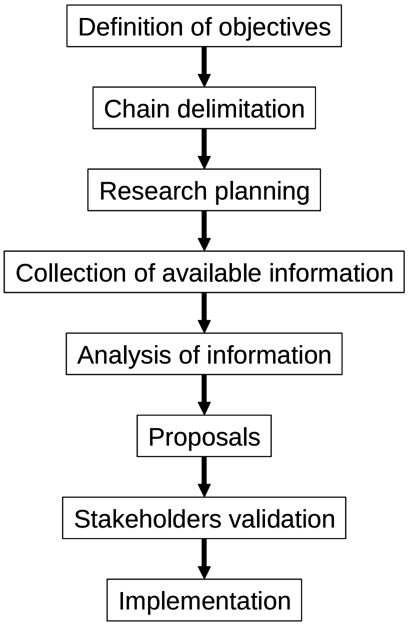


Figure 3. Steps of the Chain Analysis Methodology

The production chain analysis methodology represents the present situation of the chain. Conclusions regarding future behavior of the chain do not consider adequately the effects of feedback and delays occurring in interactions between elements of complex systems. Baatz (2006) and Silva Jr. (2007) discuss the potential of system dynamics in the evaluation of the environmental, social, and economic behavior of biodiesel production chain.

3.2 Biodiesel Production Chain

The analysis of the biodiesel production chain allows the identification of some key elements of the Biodisel Program:

1. Regular vegetal oil supply at competitive prices to biodiesel industry;
2. Guarantee of adequate yield for farmers involved in the program;
3. Impacts of biodiesel production in food supply;
4. Impacts of biodiesel production in deforestation.

From the analysis of different biodiesel production chains in Brazil, the use of byproducts of oil extraction was identified as a key point for the success of any biodiesel project. This point is directly related to the challenges of supply/price of oil for biodiesel industry and adequate income for family agriculture.

The flow of the main products and byproducts of biodiesel production chain, mainly the flow of vegetal oil/fat and the oil cake is shown below.

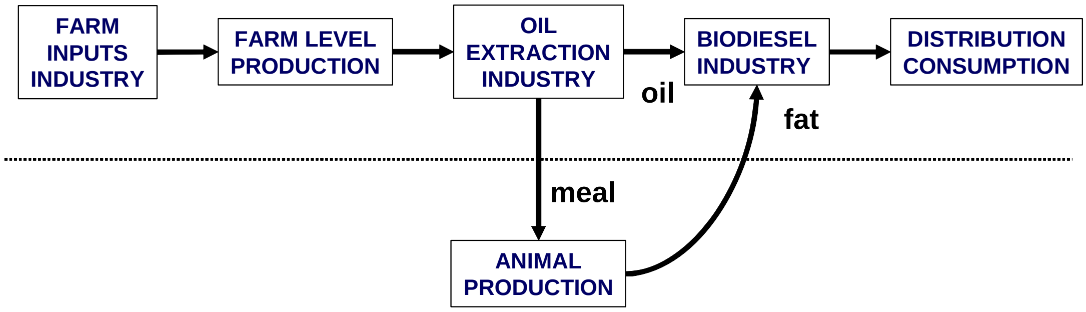


Figure 4. Product and Byproduct Flow of the Biodiesel Production Chain

The oil cake represents more then half of the weight of oil crops and contains high content of protein. This byproduct can be used to energy production. However, the high potential price that oil cake can achieve as feedstock is the main difference between the substitution programs of gasoline (Proálcool) and diesel (Biodiesel Program). The oil cake sale can allow a vegetal oil price reduction, without compromising farmers´ income, since they can be able to implement their own oil extraction plants. Coordination is the main critical element for agriculture production level and extraction industry, and has a very strong potential to affect the competitiveness of the related production chains.

The adequate utilization of oil cake is also indirectly related to food supply and deforestation. Bovine cattle breading is carried out in Brazil in extensive areas, high inefficiently regarding land use. Considering that the country has 220 millions hectares of pasture, oil crop production for the Biodiesel Program could potentially increases the production of beef and other animal products through the supply of high protein feedstock, even with the reduction of pasture area. Given the potential demand generated by the substitution of 5% of diesel in Brazil for biodiesel, the necessary area for oil crop production stays around 3 millions hectares, less then 2% of the area used nowadays for extensive cattle breading.

4. Economical Analysis with the Software Biodiesel

The Ministry of Agrarian Development (MDA) uses a specific software (Biosoft) for the analysis of biodiesel projects with family agriculture participation (Borges, 2006). The system was developed by the Federal University of Viçosa (UFV) and has been used in analyses of projects by MDA's technicians and by the own UFV team that has developed it.

The system allows the joint evaluation of the three biodiesel production chain segments: agricultural production (farm level production), vegetal oil extraction (oil extraction industry) and biodiesel production, calculating the following economic and social indicators:

1. Number of families involved in the project;
2. Monthly income per family;
3. Number of jobs created;
4. Break even point;
5. Pay-back period;
6. Net present value;
7. Return internal rate.

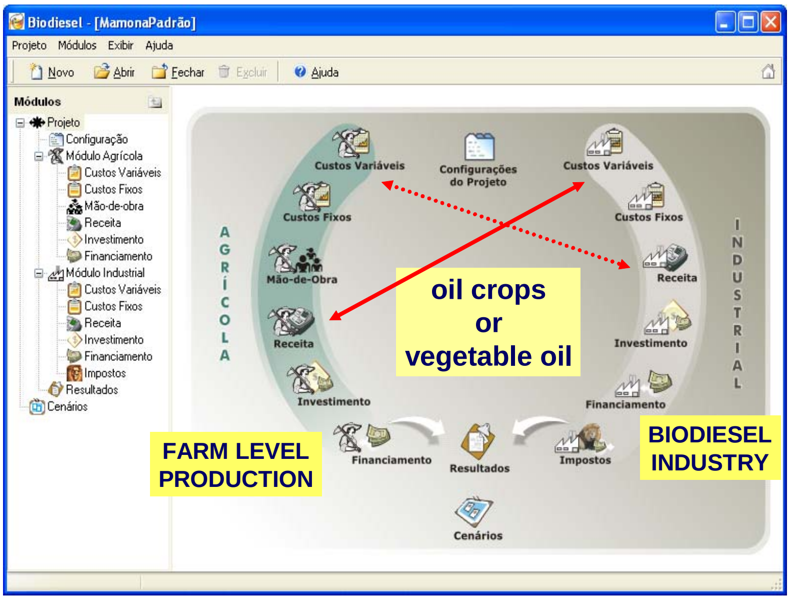


Figure 5. Structure of the Biosoft ® Software

Different productive arrangements can be analyzed. In one alternative, the oil extraction process is controlled by farmers' associations, which can sell oil and use oil cake for animal breading. The right productive arrangement is a key aspect of production chain efficiency because is directly related to the income generation with oil cake sales. The system also allows analyses of sensibility and comparison of scenarios.

5. Experience in the Analysis, Design and Implementation of Projects

UFV has already carried out feasibility analysis of 11 projects related to a cooperation project with the Ministry of Agrarian Development. Investment analysis of biodiesel projects have been also requested by a farmers´ union, Brazilian companies and a European industrial group.

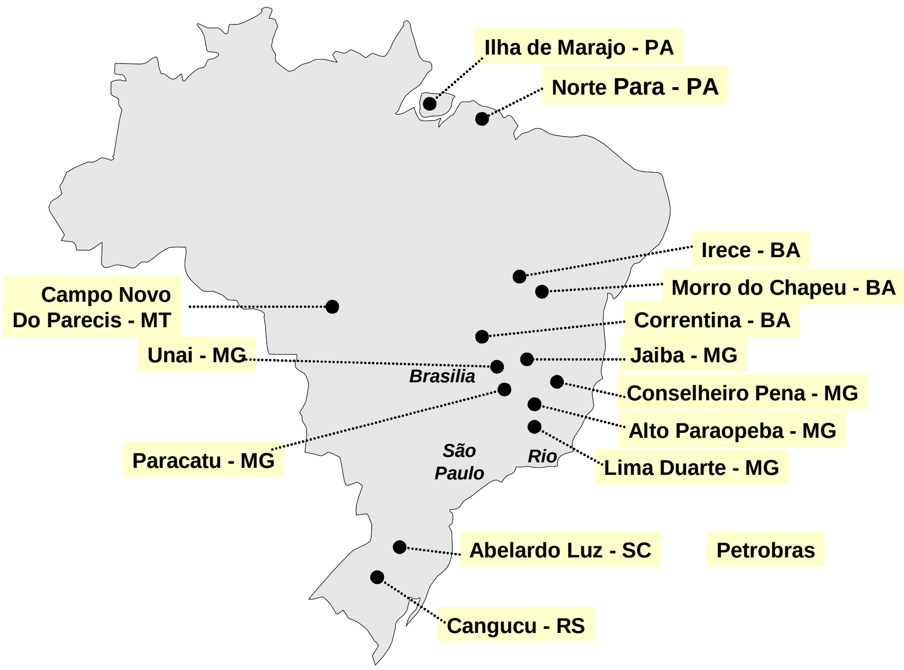


Figure 6. Biodiesel projects analysis carried out by the UFV

UFV carried out the analysis following the basic methodological structure shown in figure 3. Some phases were not implemented in some projects due to local specific conditions. However, the results reinforce the importance of oil extraction byproducts utilization. The results in some projects allowed the identification of bottleneckes related mainly to chain coordination problems, indicating in some cases the lack of feasibility (Perez, 2007).

The economic feasibility analysis carried out through the Biosoft system showed best results for projects in the north region (Projects *Ilha de Marajó* and *Norte Pará*) for palm oil production as its base. In these regions the market structure is a weak point. In general, the projects feasibility in other regions, considering agriculture and industry indicators, is highly sensitive to raw inputs price variations. The byproducts sale price is a determinant point for projects feasibility (Perez, 2007).

The last project the UFV was involved in is the Project *Unaí*, proposed by the Minas Gerais Agriculture and Livestock Federation (FAEMG), the biggest farmers union in Minas Gerais state. Besides FAEMG, the main stakeholders are: a milky farmers cooperative; two grains farmer cooperative (maize and soybean); and the Brazilian Support Service for Small and Medium Enterprises (SEBRAE-MG). The milky cooperative has already invested around US$ 5 million in a feedstock plant, with a production capacity of 30 ton/day. The northeast region, which the municipality of Unai belongs to, is the biggest soybean producing region in Minas Gerais state. However, the two grains cooperatives have to face the hard competition of two large multinational corporations, Bunge and Cargill. The idea is to analyze the feasibility of an oil extraction plant that can improve the competitive advantages of the grains cooperatives, supply the feedstock factory with oil cake, reduce the production costs for milky farmers, aggregate value to the grain produce in the region, and improve farmers´ income through oil sell in the regional and state market. Besides that, a secondary objective is to implemented financing experiments and design of contract between the segments involved in the project: farmers, oil extraction plant, feedstock factory and possible oil buyers.

6. Conclusion

The Brazilian experience of more then 30 years of use of ethanol brings important lessons to the implementation of biofuel programs in others countries. The Proálcool implementation was a consequence of a geopolitical crisis of immense proportions and potentially harmful for countries dependent of oil import at the beginning of the seventies, as Brazil.
The concentration of sugar cane, ethanol and sugar production is a frequent critic to the Proálcool. The Biodiesel Program, recently lunched in Brazil, has among its basic objectives the social integration of family agriculture to biodiesel production chains. The diversity of raw inputs (oil crops) and industrial production technologies allows the implementation of biodiesel projects all over the country. This flexibility is worthwhile for the social objective of the Biodiesel Program, but assumes great coordination capacity among the agents involved in the production chains (oil and byproduct utilization ones). Results of previous analysis helped identifying the regular supply of oil at competitive prices to be the key point to the efficiency of biodiesel production chain; and the oil cake utilization as the leverage point of chain performance.
Economic indicators calculated by the Biosoft system proved the essential role of oil cake utilization for the majority of the projects analyzed. The production chain and economic feasibility analysis allowed productive arrangements propositions with the participation of all stakeholders involved. Experiments of structuring of financial operations and design of contracts can contribute for effective decision-making that increase the performace of biodiesel production chain.
The production chain analysis is the basic instrument in the analysis of Biodiesel investments. However, its static character is a limiting factor. The incorporation of systems dynamics approach to the analyses, considering the feedback and delays effects, is highly promising.

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