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Identification of Shortfalls and Establishment of A Work plan For The Success of the Brazilian Biodiesel Program

Mauricio Cintra do Prado de Salles Penteado
University Of São Paulo Professional Master Course In Automotive Engineering polytechnic School Of The University Of São Paulo

ABSTRACT: *The Increasing Demand For The Development Of Automotive Technologies Of Less Polluting Fuel Emissions, Including That Of Alternative Fuels, Has Been The Way To Foster Biodiesel Technology, Of Non-Fossil Origin, Derived From Renewable Sources, Aiming At Gradually Substituting The Use Of Diesel Oil, In The Worldwide Energetic Matrix. The American Directive "Clean Air Act Amendment Of 1990" , The Law S-517, And The European Directive "2003/30/Ec Of The European Parliament Of The Council Of 8 May 2003" Established The Addition Of Biodiesel In Diesel Oil. In The United States, This Percentage Is Of 20%, And, In Europe, It Is Compulsory The Addition Of 2%, In 2005, And Will Be Of 5,75%, In 2010. From That Prospective, The Biodiesel Needs To Be Gradually Implemented In Brazil. The Brazilian Law 11097/05 Will Demand The Addition Of 2% (Biodiesel B2), In 2008 (Or About 840 Millions Of Biodiesel Liters, Of The Estimated Amount Of Diesel Oil Demand, Of 42 Billions Of Liters, In 2008), And Of 5% (Biodiesel B5), In 2013. The Objective Of This Project Is To Identify Some Existing Shortfalls, On An Technical-Economic Assessment, In The Brazilian Biodiesel Program, And To Establish A Workplan In Order To Achieve The Success Of This Program. In This Workplan, Possible Scenarios Are Identified, With Two Different Focus: Maximum Government Net Revenue (Via Diesel Oil Importation Replacement By Biodiesel) And Maximum Jobs Generation, In 2008 And In 2013. The Research Methodology Is Based On Bibliographic Survey And On Data*

I. INTRODUCTION

What Is Biodiesel?

Biodiesel is a mono-alquil-ester fuel of long chain fatty acids (with and without double connections), derived from renewable sources, such as fried spent oil, fatty residues of treatment plants, obtained from transesterification with short chain alcohol, methanol or ethanol, or by cracking (by acid or hydroxid catalysis) [5]; [25]. Biodiesel is a fuel able to partially or totally replace fossil diesel oil in automotive and stationary compression ignition engines (diesel cycle engines) [5]. This paper will focus on automotive applications.

Preliminary Considerations About Applying Biodiesel In Brasilstrategic Advantages:

- Biodiesel succeeds diesel oil, main consumed fuel in Brazil (more than 36 billions of litres in 2002) [5], with a forecasted 2005 demand of 40 billions of liters, which presses brazilian refinery profile;
- Biodiesel , a renewable fuel, can replace diesel fossil fuel [21];
- Biodiesel can reduce brazilian diesel importation dependance (20% of brazilian diesel consumed oil is directly imported) [5] , with corresponding values of US$ 830 milllions in 2004 [21];
- Biodiesel can viabilize the distribution of isolated regions where diesel oil is currently distributed [5];
- Biodiesel can improve agrobusiness and promote sustainable regional growth [21].

Economic and social advantages:

- Biodiesel is a renewable fuel able to generate a great deal of jobs in agricultural areas [5];
- Emission reduction from Biodiesel, particularly in big cities, represents a significant public health improvement [5];

Environmental and energetic advantages:

- Biodiesel usage provides, on an environmental prospective, significant improvement, both in emmisions reduction, and in diesel engines CO_2 energetic exchange, combusted and absorbed, in agricultural growth production [5];
- 1 ton of Biodiesel usage incurs in 2.5 tons of CO_2 reduction [21];
- Biodiesel provides dillution of contaminants if mixed with Diesel oil, such as sulphur content [5];

Technological advantages:

- Biodiesel mixed with Diesel oil tends to improve the Diesel oil characteristics – increase lubicity (important for diesel oil with low sulphur content), reduce sulphur content, increase cetane number [5] .

II. AGRO-ECONOMIC ASPECTS OF BRAZILIAN BIODIESEL PRODUCTION

Northern region: the high pluviometric rate and the characteristic of a non-temporary plantation region are both favourable of palm oil production, with high productivity till 5000 kg / hectare. However, the critical point is that the return on investiment comes only after 5 years, if counted from its plantation date.

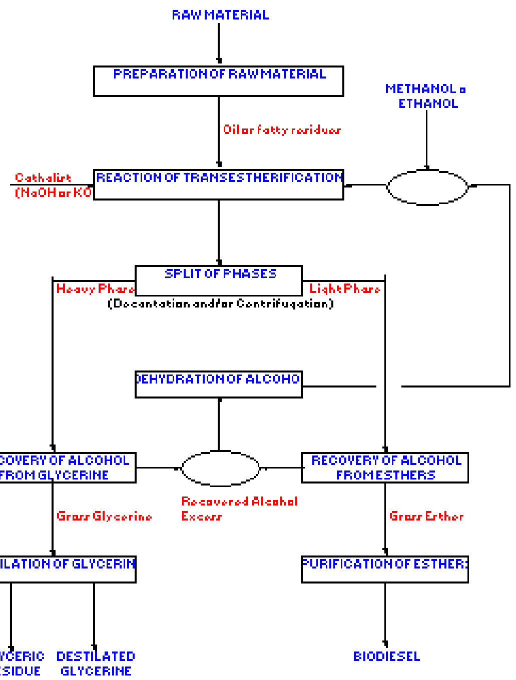
Central-Western region (except for Mato Grosso do Sul state): this region, characteristic of babassu palm forests, is favourable for coconut, castor and sun flower oils. However, as such processes are still hand-madeones, soybean is the alternative plantation.

Northeastern semi-arid region: this region coverste so-called "Dry-Polygon", with low pluviometric rate, favourable for the production of castor, with a productivity until 2500 kg/hectare. It is also favourable of family production, besides its fertility potential. However, the main problems are its very high cost (the most expensive among tall other ones) and its high viscosity, not wishfull regarding usage aspects.

South-Eastern, South regions and Mato Grosso do Sul state: these regions are favourable for temporary and mechanized plantations, like the soybean oil. The big advantage is its disposal of 96% of the whole amount of Brazilian oils, which fosters price reduction. However, the main problem is its oxidation stability (low, if compared to the remaining ones), which is not wishfull regarding usage aspects.

III. TECHNOLOGICAL ASPECTS OF BIODIESEL PRODUCTION

Figure 1 – Biodiesel Production Process Flowchart [22]



In the following process steps which will be described below, and identified in Figure 1, some alcohol excess is necessary to increase the conversion efficiency, and allow the subsequent split of esthers from glycerol [13]; [22].

Preparation of raw material

It is necessary to have the raw material with minimum humidity and acidity via sodium or potassium hydroxide, followed by a drying or dehumidification step [22].

Transestherification process

It is the step of oil or fatty residue conversion in methylic or ethylic greased acid esthers, which is the Biodiesel. The reaction is shown by the following chemistic equation [22]:

- Oil or Fatty Residue + Methanol ➔ Methylic Esthers + Glycerol
- Oil or Fatty Residue + Ethanol ➔ Ethylic Esthers + Glycerol

Ethylic transestherification is more complex and slower than methylic transestherification, due to the azeotropic nature of ethanol. The alcohol recovery process is more complex and more expensive than that of methanol [4]. Table 1 shows the comparison between methylic and ethylic esthers [13]:

Table 1 – Comparison of methylic and ethylic esthers [13].

Properties	Esthers	
	Methylic	Ethylic
Conversion (oil => Biodiesel)	97.5%	94.3%
Total Glycerine in Biodiesel	0.87%	1.40%
Viscosity	3.9 to 5.6 cSt (40°C)	7.2% superior to methyl esther
Power decrease compared to Diesel Oil	2.5%	4%
Consumption increase compared to Diesel Oil	10%	12%

Currently in Brazil, the advantage of the ethylic route is the ethanol offer, available in the whole country (from which the previous “Pro-alcohol” experience hás been used). Nevertheless, methanol is prevaily used, in worldwide scale.

As for the technical-economic aspect, methanol route is more advantegeous than that of ethanol. Table 2 shows its corresponding advantages [22]:

Table 2 – Comparison of ethylic and methylic routes [22]:

Average usual quantities and conditions	Process routes	
	Methylic	Ethylic
- Consumed alcohol (Kg) per 1000 liters of Biodiesel	90	130
- Average Alcohol price (US$ / kg)	190	360
- Recommended excess of recovered alcohol, by destilation, after reaction	100%	650%
- Recommended reaction temperature	60°C	85°C
- Reaction timing (minutes)	45	90

The most applied catalists are sodium hydroxide (NaOH) and potassium hydroxide (KOH). The KOH is more expensive than KOH, but generates less saponification problems. Sodium methoxide is the best catalyst, but is more expensive.Acids are much slower in process than non-acids (about 1000 times as slow as non-acids). It would be the ideal solution to have heterogeneous catalysts (which are not soluble in reaction process, and could be reused and regenerated). The heterogeneous catalysis is still not fully developed in Brazil [4].

The advantages of the application of enzimes as catalysts, if compared to acids and non-acids catalysts, are: less sensitivity to water, catalyst recovery and Biodiesel split, despite its higher cost [13]. Nevertheless, it provides additional advantages in that [3];[5]:

- it allows the production of specific alquil-esthers;
- it allows the easier glycerol recovery;
- allows glycerideous transestherification with high free acids content;
- it allows the introduction of other characteristics in produced alquil-esthers, resulting in the improvement of Biodiesel low temperature properties;
- the heterogeneous catalyst does not produce soap;
- the heterogenous catalyst is reusable;
- the heterogenous catalyst prevents the neutralization step.

Split of phases

After all the greased material transestherification in Biodiesel, the final reaction mass is formed by two phases, splittable by decantation and/or centrifugation (the latter, applicable, if process speeding is desirable) [22].

The heavier step is composed by gross glycerin, impregnated by used excess of of alcohol, water and inherent impurities of raw-material. The less dense phase is composed of a mixture of methylic or ethylic esthers (depending on the applied alcohol), also impregnated by reactional excesses of alcohol and impurities [22].

Alcohol recovery from glycerine

The heavy phase, which contains water, alcohol and glycerin, is submitted to a low-pressure evaporation process called "*Flash evaporation*" [13], eliminating, thus, from the gross glycerine, these volatile components, of which vapors are liquefied in an appropriate condenser. Alternativelly, destilation process can be applied. The obtained by-product is gross glycerine [22].

Alcohol recovery from esthers

Likewise, but separatedly, the remaining alcohol is recovered from the lighter phase, releasing, thus, for the following steps, the methylic or the ethylic esthers [22].

Dehydration of alcohol

The residual excesses of alcohol, after its recovery processes, has significant quantity of water, requiring, thus, a splitting process. Dehydration process is normally done by destilation [22].

As for methanol dehydration, the destilation is very simple and easy to be conducted, once the relative volatility of the components is very high, and azeotropic phenomenon does not exist to complicate the complete splitting process [22].

Ethanol dehydration is more complicated, due to its azeotrophy associated with its not so high volatility [22].

Esthers purification

The esthers shall be washed by centrifugation, and subsequently dehumified, in order to have the Biodiesel, of which characteristics should be within technical specifications for Biodiesel in Diesel cycle engines. In some cases, warmed water is used to remove residues from catalysts and soaps [22].

Glycerine destilation

The emerging gross glycerine, even with its conventional impurities, would itself be a salable product. However, marjket is much more favorable of selling purified glycerine, with a better price value [22].

Soybean methylic transestherification compared to that of ethylic for the north-eastern region

The preference for castor route, for the north-eastern region is given by the following reasons [19]:

- methanol is cheaper than ethanol;
- methanol is more reactive than ethanol (requiring less reacting time);
- methanol requires less excess than ethanol;
- methanol excess can be recovered while azeotropic ethanol should not be reused, thus incurring in higher reagent flux (and higher costs);
- 80% of the consumed methanol in Brazil is produced internally, thus allowing production increase if affacted áreas are interested, particularly regarding recently discovered gás reservoirs;

- castor reaction with ethanol is of more difficult to obtain Biodiesel than ethanol, resulting in higher tratment costs and final product costs.

Finally, ethanol offer is about 30 times as much as that of ethanol, besides the fact of being generated by biomass, meaning a higher gas emmission potential of glass house effect and social development. Another point to be highlighted is that of ethanol manipulation is not dangerous, although this is only appliableduring the fabrication process, once whatever Biodiesel source hás the same toxidity level [19].

Production Costs Of Biodiesel And Its Generated By-Products

The following parameters and data should be stressed in order to enable Biodiesel costs calculation, as per Table 3:

- the calculation cost is based on the type of oilseed raw material;
- the calculation cost considers a certain average timing period cost;
- the calculation cost should consider, in its transetherification process, if it is of ethylic or methylic route, besieds its catlist process (homogeneous or heterogeneous);
- the calculation cost should consider the production scale (small, medium or big size industry);
- incident tributes should be considered only in final cost, depending on the production scale and the technological route.

There are still not definite data, but, rather, infered data for such costs calculation, and there are also considerable variations of the achieved values found in different brazilian publications from 2003 and 2005. The main reason is that the addition of 2% of Biodiesel in Diesel oil (B2) will be compulsory only in 2008, as per Regulatory Law 11.097/2005. Therefore, only basic cost consideration will be presented in this paper, regarding Biodiesel costs.

As previously mentioned, the calculation cost will consider the trasestherification process via heterogenous catalysis.

The main shortfall for the consolidation of the Brazilian Biodiesel Program is the price gap between the petrol and the oil seeds [5].

The basic additional premisses for the calculation costs are as follows [5]:

- it does not consider the oilseed variation cost relating to consumption increase for Biodiesel production;
- it does not consider freight costs (which could impact in final customer cost, compared to that of Diesel oil);
- it does not consider the investiment needs in infra-structure and oil seed(s) raw-material;
- it considers the soybean oil price in international market;
- it considers the ethanol price in the brazilian market;
- it considers the sodium hydroxide price in the brazilian market;
- it considers the glycerine commercialization in the brazilian market;
- it considers the Diesel oil cost without tributes = R$ 0,76 / litro;
- it considers the Biodiesel average density of 0,87 g/cm^3 = 0,87 x 10^{-3} tons/liter;
- it considers the dollar average quotation of US$ 1,00 = R$ 2,50;
- the Biodiesel final cost conversion, without tributes, from US$ / tons, to R$ / liter, will be based on the relation:

  US$ 1,00 / tons = R$ (1/460) / liter;
- the costs of soybean, castor and palm are reffered to “MB do Brasil, 2005” website.

The basic formulation to calculate the Biodiesel cost is as follows [5]:

Biodiesel cost = (price of soybean oil) + (price of ethylic alcohol) + (price of sodium hydroxide) + (energy cost) + (vapor cost) – (glycerine price)

A tentative inference is made in Table 3, aiming at proceeding with a sensitivity analysis of incident costs in Biodiesel, from its corresponding oilseeds, bearing in mind a Biodiesel production plant of 400 tons a day [5]; [17].

Table 3 – Sensitivity analysis of Biodiesel costs

Cenario 1 for South-Eastern, South and Central-Western regions: Ethylic Soybean Biodiesel (without tributes)

Item	Price [US$/t or US$ / (KWh/t)] Min	Max	Average	Quantity (Kg or KWh)	Cost (US$/t) Min	Max	Average
Soybean oil	270	648	459	965	260,55	625,32	442,935
Ethanol	140	350	245	156	21,84	54,6	38,22
NaOH	740			15	11,1		
Eletrictricity	50,4			35	1,764		
Vapor	10			76	0,76		
Glycerine	450			104	46,8		
				Total	249,214	646,744	447,979
Impact in final cost without tributes (R$/L)					0,54177	1,405965	0,973867

Comparative Cenario 2 for South-Eastern, South and Central-Western regions:Methylic Soybean Biodiesel (without tributes)

Item	Price [US$/t or US$ / (KWh/t)] Min	Max	Average	Quantity (Kg or KWh)	Cost (US$/t) Min	Max	Average
Soybean oil	270	648	459	965	260,55	625,32	442,935
Methanol (45% below)	77	260	168,5	86	6,622	22,36	14,491
NaOH	740			15	11,1		
Eletrictricity (50% below)	50,4			17	0,8568		
Vapor (80% below)	10			15	0,15		
Glycerine	450			104	46,8		
				Total	232,4788	612,9868	422,7328
Impact in final cost without tributes (R$/L)					0,505389	1,33258	0,918984

Table 3 (continuation) – Sensitivity analysis of Biodiesel costs

Cenario 3 for North-Eastern region: Methylic Castor Biodiesel (without tributes)

Item	Price [US$/t or US$ / (KWh/t)] Min	Max	Average	Quantity (Kg or KWh)	Cost (US$/t) Min	Max	Average
Castor oil	459	1101	780	965	442,935	1062,465	752,7
Methanol	77	260	168,5	86	6,622	22,36	14,491
NaOH	740			15	11,1		
Eletrictricity	50,4			17	0,8568		
Vapor	10			15	0,15		
Glycerine	450			104	46,8		
				Total	414,8638	1050,132	732,4978
Impact in final cost without tributes (R$/L)					0,901878	2,282895	1,592387

Cenario 4 for North region: Ethylic Palm Biodiesel (without tributes)

Item	Price [US$/t or US$ / (KWh/t)] Min	Max	Average	Quantity (Kg or KWh)	Cost (US$/t) Min	Max	Average
Palm oil	32	88	60	965	30,88	84,92	57,9
Ethanol	140	350	245	156	21,84	54,6	38,22
NaOH	740			15	11,1		
Eletrictricity	50,4			35	1,764		
Vapor	10			76	0,76		
Glycerine	450			104	46,8		
				Total	19,544	106,344	62,944
Impact in final cost without tributes (R$/L)					0,042487	0,231183	0,136835

IV. ANALYSIS OF BIODIESEL PRODUCTION PROCESSES FROM RESIDUES (FRIED OILS, GREASED RESIDUES, SOLID URBAN WASTES, AMONG OTHERS)

The main advantages are as follows [19]:

- the brazilian equipments and raw-material are of brazilian origin, and, therefore, quoted in brazilian currency;
- they are intensive, in manpower, once they require residues selection, in order to obtain residual biomass and recycable material, and residual raw-material for Biodiesel production – and cultivation and extraction, in order to obtain new raw-material for Biodiesel;
- they are normally available together with the consumers, reducing, thus, the transportation cost;

- although still not representative, on a global scale, the residual raw-material for Biodiesel production, comprehending fried oil, greased acids, fat and waste residues, besides their reduced costs, they have the advantage of being available in urban areas.

There is a Biodiesel production process from urban waste, of which patent request is underway, of which matrial is still not available for publication, except for the bibliographic reference, accessible in www.ppe.ufrj.br, doctorate thesis of September 2004, from professo Doctor Luciano Basto Oliveira [19]. This raw-material, although available in the scale of 10 millions of liters a year for fried oil Biodiesel and 250 millions of liters a year for cattle tallow Biodiesel, show the advantage of their immediate availability, consumers proximity, continuous production (a type of urban extractiion), low production cost and a pollution reduction potential, besides the potential for technology exportation.

V. SENSITIVITY ANALYSIS OF BIODIESEL COSTS, FROM FRIED OIL AND CATTLE TALLOW OIL

Bearing in mind the same hypothesis in the previous topic, and also by making a cost inference, based on Professor Dr. Luciano Basto Oliveira's doctorate thesis [19], a sensitivity analysis of Biodiesel is tentativelly being made, relating to fried oil and cattle tallow Biodiesel, as per Table 4.

Table 4 – Sensitivity Analysis Of Biodiesel Costs From Residues

Cenario 1: Ethylic Fried Oil Biodiesel (without tributes)

	Price [US$/t or US$ / (KWh/t)]			Quantity (Kg or KWh)	Cost (US$/t)		
Item	Min	Max	Average		Min	Max	Average
Fried Oil	108	259	183,5	965	104,22	249,935	177,0775
Ethanol	140	350	245	156	21,84	54,6	38,22
NaOH	740			15	11,1		
Eletrictricity	50,4			35	1,764		
Vapor	10			76	0,76		
Glycerine	450			104	46,8		
				Total	92,884	271,359	182,1215
Impact in final costs without tributes (R$/L)					0,201922	0,589911	0,395916

Cenario 2: Comparative Analysis for Methylic Fried Oil Biodiesel (without tributes)

	Price [US$/t or US$ / (KWh/t)]			Quantity (Kg or KWh)	Cost (US$/t)		
Item	Min	Max	Average		Min	Max	Average
Fried Oil	108	259	183,5	965	104,22	249,935	177,0775
Methanol (45% below)	77	260	168,5	86	6,622	22,36	14,491
NaOH	740			15	11,1		
Eletrictricity (50% below)	50,4			17	0,8568		
Vapor (80% below)	10			15	0,15		
Glycerine	450			104	46,8		
				Total	76,1488	237,6018	156,8753
Impact in final costs without tributes (R$/L)					0,165541	0,516526	0,341033

Table 4 (continuation) – Sensitivity analysis of Biodiesel costs from residues

Cenario 3: Methylic Cattle Tallow Biodiesel (without tributes)

	Price [US$/t or US$ / (KWh/t)]			Quantity (Kg or KWh)	Cost (US$/t)		
Item	Min	Max	Average		Min	Max	Average
Cattle Tallow	147	354	250,5	965	141,855	341,61	241,7325
Methanol	77	260	168,5	86	6,622	22,36	14,491
NaOH	740			15	11,1		
Eletrictricity	50,4			17	0,8568		
Vapor	10			15	0,15		
Glycerine	450			104	46,8		
				Total	113,7838	329,2768	221,5303
Impact in final costs without tributes (R$/L)					0,247356	0,715819	0,481588

Cenario 4: Comparative Analysis of Ethylic Cattle Tallow Biodiesel (without tributes)

	Price [US$/t or US$ / (KWh/t)]			Quantity (Kg or KWh)	Cost (US$/t)		
Item	Min	Max	Average		Min	Max	Average
Cattle Tallow	147	354	250,5	965	141,855	341,61	241,7325
Ethanol	140	350	245	156	21,84	54,6	38,22
NaOH	740			15	11,1		
Eletrictricity	50,4			35	1,764		
Vapor	10			76	0,76		
Glycerine	450			104	46,8		
				Total	130,519	363,034	246,7765
Impact in final costs without tributes (R$/L)					0,283737	0,789204	0,536471

VI. TECHNOLOGICAL ASPECTS OF BIODIESEL UTILIZATION

The characteristics of an adequate fuel for compression ignition engines are as follows [5]:

- optimal ignition quality: combustion should initiate in the right timing;
- complete vaporization in the combustin chamber, aiming at achieving:
  - ⇨ correct blend with air;
  - ⇨ clean and complete combustion, in order to achieve:
    - better engine perfomance;
    - reduction of pollution emissions;
    - reduction of formation of residues, deposits and ashes;
- not to be corrosive;
- not to have water and sediments (less engine wear);
- maintain its adequation for the maximum forecasted storage;
- it should be based in physical-chemical properties of the final product rather than in its oilseed source;
- it should achieve agreement among refiners, engine suppliers, Biodiesel producers and environmental entities;
- it should bear in mind the Diesel oil specification;
- it should evolute together with Diesel oil specification;
- it should include the limits for peculiar characteristics of Biodiesel.

Some basic characteristics will be assigned below. Although some values are for Diesel oil, the concepts are also appliable for Biodiesel [1].

Cetane number

The easiness of having the combustion is called Ignitability, and is related to essencial properties of the fuel, which are the calorific value and the cetane number. The cinematic viscosity and superficial tension, as used to define the pulverization quality in fuel injection, also contribute as factors of combustion quality [22].

The less this timing is, the bigger the ignition quality and the cetane number are (or cetane index, if obtained by calculation), whereas bigger ignition delays produce a characteristic noise called "Diesel detonation", due to the very fast burning of the whole Diesel ingressed into the combustion chamber during its timing delay.

As the Biodiesel cetane number is bigger than that of Diesel, Biodiesel provides a much better engine burning than Diesel [22].

Lubricity [22]

The lubricity is the lubrication power of a substance, by being a function of several physical properties, especially the viscosity and the superficial tension.

Unlike gasoline engines, Diesel engines require lubrication properties, especially due to the pump functioning, demanding the flowing liquid to be adequatelly lubrify its moving parts.

Mist and Fluidity point [22]

Mist point is the temperature in which the liquid, by refrigeration, begins to be muddy, and Fluidity point is the temperature in which the liquid begins not to freely flow.

Both the mist point and the fluidity point of Biodiesel vary, according to the oilseed origin, as well as the alcohol used in the transestherification process.

These properties are important regarding the environmental temperatures where the fuel should be stored and used. Nevertheless, in Brazil, from North to South, the temperatures are mild, without showing problems of fuel freezing, mainly because it is intende to used Biodiesel blended with Diesel.

Flash Point and Volatility [1]; [22]

Flash Point is the temperature in which the liquid begins to be inflamable, with flame or spark. This property is specially important regarding transportation security, handling and storage. Biodiesel flash point, if completely free from methanol or ethanol, is superior to environmental temperature, meaning that the fuel is not inflamable in normal conditions where it is transported, handled and stored. The volatility is evaluated by destilation test. The lighter fractions of Diesel and those of lowest boiling points, should be controlled, regarding security reasons of handling, transportation and storage, due to the risk of inflameability.

The limitation of the minimum flash point, in the international specifications, assures these security issues, and, for european countries of big Diesel consumers,a value of 55^o C mimimum is specified. The brazilian specification does not cover such flash point limitations, except for maritime applications, where s T50% is defined to guarantee a certain balance in destilation curve. Due to the higher minimum temperatures in Brazil, a Clogging Point is similarly defined, once it is the test which best adapts to the brazilian conditions (ANP, 1997).

Heat of Combustion [22]

The heat of combustion of a fuel indicates the fuel developed energy, by mass unit, when it is burned. As for engine fuels, burning means combustion in engine functioning. The Biodiesel calorific value is close to that of Diesel. The average difference is about 5%.

Density [1]

Diesel engines have their optimal point calibrated for a defined fuel density regarding the injection pump, which gives a injected volume for each operating condition. Although they can operate with Diesel within a range of densities, the pumping can show problems if such range is too large. Too high densities lead to a high quantity of fuel in na air-fuel blend, causing increase in particulated emissions, carbon monoxide and hydrocarbons, whereas tôo low densities lead to loss of power and driveability, besides fuel consumption increase.

Sulphur content

Undesirable elemt in any fuel, suphur forms compounds which cause engine wear, both by corrosion and by deposits. Sulphur oxides from the combustion form sulphur acid, in the presence of water, attacking cylinders and rings, mainly in cold start and engine heating [22]. As for the atmospheric pollution, suplhur influence in particulated emissions, both via direct particles (metallic sulphates) and via indirect particles (ammonia sulphates, responsible for acid rain) [1]. Sulphur and aromatic hydrocarbons are also parameters to evaluate engine durability [22]. There is a particularity relating to NOx emission in which, until 13%, could be minimized by the use of catalysts. There is a need to bear in mind that catalysts are not viable to be used in diesel engines in Brazil, due to their high sulphur and particulated material content in Diesel oil. Thus, Biodiesel consumption will allow the utilization of catalysts, able to reduce the pollution [19].

Characteristics and peculiarities of the Biodiesel (Department of Energy, 2001):

- the increase in the size of the carbon chain raises the mist point, the cetane number , reduce NOx content and increases the stability (examples: C14:0, C16:0, C18:0);
- the increase in the number of double chains (examples: two:(C18:2), or three: (C18:3)) reduce the mist point, the cetane number, the stability (unless aditives are used) and raise NOx content;
- Biodiesel density between 0.87-0.88 g/cm^3, is slightly bigger than that of Diesel, of about 0,85 g/cm^3;
- Biodiesel does not contain nitrogen or aromatics, and, normally, it contains less than 15 ppm of sulphur; it contains 11% of oxigen, in mass, responsible for its slightly inferior calorific value, and it contains, in combustion with Diesel, low values of carbon monoxide, particulated material and hydrocarbons;
- Fuel consumption, power and torque are proporcional to the calorific value of Biodiesel or of the Biodiesel/Diesel blend. For example, Biodiesel B20 tends to have less power, less torque and more fuel consumption than Biodiesel B2.

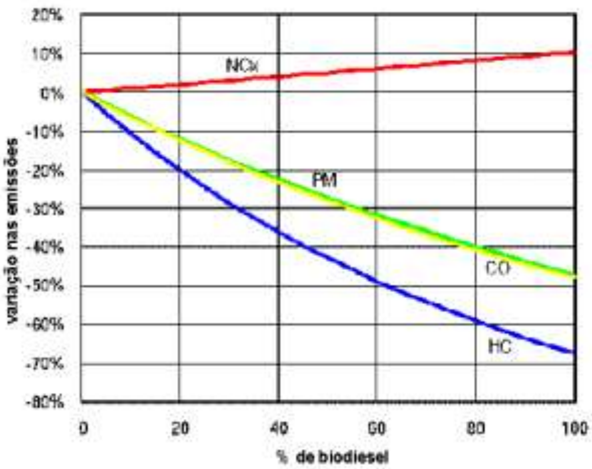
Table 5 shows the composition of some greased acids of vegetable oils (remark: "No de duplas" means "number of double chains") [5]:

Table 5 – Composition of greased acids in some vegetable oils [5].

Componente	Nº Duplas	Fórmula	Babaçu	Dendê	Colza	Soja
Caprílico	0	$C_7H_{15}COOH$	4 – 7			
Cáprico	0	$C_9H_{19}COOH$	3 – 6			
Láurico	0	$C_{11}H_{23}COOH$	44 – 46			
Mirístico	0	$C_{13}H_{27}COOH$	15 – 20	1 – 3	1	1 – 2
Palmítico	0	$C_{15}H_{31}COOH$	6 – 9	35 – 43	1	6 – 10
Esteárico	0	$C_{17}H_{35}COOH$	3 – 5	3 – 5	1 – 2	2 – 4
Oleico	1	$C_{17}H_{33}COOH$		34 – 56	25 – 30	20 – 30
Linoleico	2	$C_{17}H_{31}COOH$		9 – 11	14 – 15	50 – 58
Linolênico	3	$C_{17}H_{29}COOH$				4 – 9
Erúcico	1	$C_{21}H_{41}COOH$			43 – 57	
Índice de Iodo			9 – 18	50 – 60	94 – 102	125 – 140

- Biodiesel flash point is usually bigger than 150°C; the value was fixed in 100° C to assure that the supplier removes all the used methanol or ethanol excess in the manufacturing process; the residual content of ethanol or methanol is a security requirement, because low contents reduce the flash point. Methanol or ethanol can affect fuel pumps, sales, gaskets, and may lead to a poor combustion process;
- sulphur content test is done to assure the removal of all the process catalysts;
- the acidity index increases with the fuel aging, or if the fuel is not correctly manufactured; values above 0.10 are normally associated with fuel deposits, reducing the fuel pumps and the filters life;
- the total and free glycerin content are used to measure the complete conversion of residues and oils in Biodiesel; if these numbers are tôo high, the fabrication process is not adequate, and engine deposits will occur; fuels with total and free glycerine content above specified limits should not be used;
- the stability test methods can determine if the fule will remain stable, during storage for long period of time; high acidity indexes with high viscosity indicate fuel degradation;
- the increase of Biodiesel blend in Diesel shows the following effect in emission, as per Figure 2 [13]

Figure 2 – Effect of Biodiesel content increase in emissions content [13].



VII. TESTS – REQUISITES, CONSIDERATIONS AND TIMING

The tests for new fuels with Biodiesel B2, should be in accordance with Brazilian governmental decree 240/2003, from “ANP” (“Nacional Petroleum Agengy”), which establishes the regulation for non-specified fuels use [5].

Many test procedures, as well as their timings, are still not available for publication, bacause they are still being subjected to governmental approval.

Just for the sake of an inference, tests are being suggested whereby, initially, physical-chemical certification tests should be pursued. Subsequently, fleet controlled tests could simoutaneously, on a comparison basis, be pursued, with B2 and B5. Additionally, dynamomter tests are suggested, for a period of 1 year, and vehicle fleet controlled, for a period of 2 years. Some components and engine/injections systems are also suggested, as follows:

- oil and fuel filters: registration of consumption, registration photographs of deposits, cloggins and chemical attacks;
- injection pumps and combustion chambers: registration photograps of cloggings, obstructions, injection pressure, saponification and greased acids;
- lubricant oils: registration of consumption and dillution;
- Biodiesel in Diesel oil registration of consumption, density, cinematic viscosity, acidity index, dillution, saponification and greased acids, ashes content and sulphur content.

These tests shall cover all injection systems, such as, rotating pumps and common rail, for light commercial vehicles, with electronic injection (pick-ups, vans and mini-buses), and unit pump and unit injectors with common rail, for medium and heavy commercial vehicles, also with electronic injection.

The characteristics of these tests are as follows [5]:

- they shall have previous authorization of ANP, for wider consumption than 2000 kg/month;
- they are experimental tests;
- they shall be done in fleet tests or in specific industrial processes;
- they shall be done in a scheduled timing;
- they shall have an environmental appraisal;
- they shall have a product handling security report

Influence of Biodiesel physical-chemical properties in injection systems performance
Table 6 shows the influences of the physical-chemical properties in injection systems [30]:

Table 6 – Influences of the physical-chemical properties in injection systems [30].

Density

Low	Less torque and power (less energetic content) calibration revision may be required
High	More torque and power (more energetic content)
	More pressure in cam-controlled mechanical systems: engine and injection systems calibration re-evaluation may be required
	Less injected quantity in timing-controlled systems (CRS): less power

Viscosity

Low	Increase in diesel leakings: hot start and idle conditions may be affected
	Wear increase in parts with relative movement, due to the thinner hydrodinamical film and less absorbed oscilations
	More injected quantity in timing-controlled systems (CRS): more smoke
High	Pressure increase in mechanical injection system: components application may be re-evaluated
	More pressure gap in fuel filters
	More injected quantity in timing-controlled systems (CRS): less power

Oxidation stability

Low	Corrosion in injection system components
	Deposits of aging produts in internal components of injection systems
High	No influence

Biodiesel direct and indirect influence in electronic systems

Although there is an agreement, among systemist suppliers Delphi, Bosch, Denso, Siemens, Stanadyne and Siemens VDO, dated July 2004, to attend european specification EN 14214, until 5% of Biodiesel addition in Diesel, without modification of injection system components [9], denominated "direct influence of Biodiesel in electronic systems", there is a need to remind:

- the influence that Biodiesel makes in calibration parameters of injection systems of Biodiesel x Diesel blend (denominated "indirect influence of Biodiesel in electronic systems") for all blend levels;
- the direct and indirect influence of the Biodiesel, in proportions of more than 5%, in electronic systems, such as hot and cold start.

Dinamometer bench tests realized by the University of Rio de Janeiro team (COPPE/UFRJ), in conjunction with the Institute of Technological Research (IPT) – São Paulo

The reffered tests were realized with 5% of Biodiesel in Diesel (B5) by the team of the University of Rio de Janeiro (UFRJ) in conjunction with the tean of the Institute of Technological Research (IPT) - São Paulo. The tested Biodiesels were Soybean Biodiesel (B5 S) and Fried Oil (B5 F), of which description of Biodiesel Viabilization Use Project is shown in Table 7 [26]:

Table 7 – Results of IPT dynamometer bench tests [16]; [26].

University of São Paulo Technological Research Institute ("IPT") Bench Test results

	Absolute values			Variations	
Measured parameter	Base Diesel	B5 Soybean	B5 Fried oil	B5 Soybean	B5 Fried oil
Effective power (KW)	50.8	50.6	50.9	-0.5%	0.2%
Specific consumption (g / KW.h)	189.8	190.7	191.0	0.5%	0.7%
CO (g / KW.h)	0.93	0.91	0.92	-1.6%	-1.6%
NOx (g / KW.h)	6.66	6.72	6.71	0.9%	0.8%
THC (g / KW.h)	0.426	0.423	0.424	-0.8%	-0.6%
Smoke-black (g / KW.h)	0.041	0.038	0.033	-5.6%	-19.9%
Measured particulated material (g / KW.h)	0.169	0.162	0.163	-4.1%	-3.5%

- There was a slight calibrated power reduction for B5 S, unlike that of B5 F;
- in both cases, the specific fuel consumption is a little bit higher than that of the base diesel, about 1%;
- except for NOx, there was e reduction in all emissions, particularly in smoke black of B5 F ;
- the NOx emission increase was less than 1%

The conclusions which can be done about the test results are the following:

- the Biodiesel power reduction, compared to that of Diesel, is due to its lower calorific value;
- the NOx content is slighter bigger than that of Diesel. The reason behind it is that, during the transestherification process, Nitrogen in the air is captured, resulting the NOx generation during its reaction, unlike the case of Diesel, of fossil origin;
- the reduction of CO, smoke-black and particulated material are due to the fact that Biodisel hás less residual carbon content, and bigger cetane number compared to that of Diesel.

VIII. PROPOSED SPECIFICATION FOR BIODIESEL B2 FOR THE BRAZILIAN BIODIESEL PROGRAM

Several comparative charts have been generated by several entities, including also that of ANP, aiming at introducing and adequating Biodiesel B2 into the Brazilian Biodiesel Program, as per the brazilian Law N^o 11.097, dated January 13th 2005, which authorizes the non-compulsory introduction of Biodiesel B2 until 2008. The idea is to provide the brazilian productive chain with time to organize itself, until such introduction becomes compulsory, in 2008.

Additionally, Some Remarks Shall Be Made, Regarding:

○ **The Brazilian Market:**

⇨from 2005 to 2008, the introduction of Biodiesel B2, in the Brazilian Biodiesel Program, will be optional (market structuring phase);

⇨in 2008, Biodiesel B2 will be compulsory in the brazilian market;

⇨from 2008 to 2013, the introduction of Biodiesel B5 in the Brazilian Biodiesel Program, will be optional (market maturation phase);

⇨in 2013, Biodiesel B5 will be compulsory;

○ **The European Market**:

⇨in 2005, the introduction of Biodiesel B2, in the European Biodiesel Program, is compulsory;
⇨from 2005 to 2010, the introduction of 5.75% of Biodiesel will be optional;
⇨in 2013, the introduction of Biodiesel B5.75% will be compulsory;
The Attachment 1 aims at specifying the introduction, in the brazilian market, of the Biodiesel B2, for 2008, within the Brazilian Biodiesel Program.

The most significant parameters, in Biodiesel quality, are as follows [5]:

- free glycerine removal **(free glycerine content)**;
- residual cathalyst removal **(ashes content)**;
- reagent alcohol removal **(flash point)**;
- lack of free greased acids **(total acidity)**

The most indicative performance parameters in the injection systems are as follows [5]:

- viscosity;
- specífic mass (density);
- oxidation stability

For the sake of an additional suggestion, an extra column, in Attachment 1, denominated "Alternative or additional proposal", was added, in order to cover both the ANP proposals and the above mentioned improvement parameters.

IX. GLOBAL TECHNICAL-ECONOMIC ANALYSIS OF BIODIESEL

Basic considerations and simplified hyphothesis for the obtained results analysis, which will follow, from Attachments 2 to 5:

- price changes in relation to volume are not being considered;
- emissions reduction level benefits are not being considered;
- the following scenarios are being considered:

- scenário (A): substitution of Diesel oil importation by Biodiesel ;
- scenário (B): introduction on Disel oil / Biodiesel in light vehicles (currently forbidden);
- scenário (C): composition of the scenários (A) and (B)

- firstly, in order to viabilize the sequence of steps in Attachment 3, a sensitivity analysis of Biodiesel costs is made, in comparison to that of Diesel oil, as per Attachment 2. Similarly, the same type of calculation is made, by comparing the Biodieselwith the weighed price value of gasoline "C" (that is, light vehicles using gasoline with 25% of alcohol in Brazil). In this regard, the steps, in Attachment 2 are as follows:

⇨ percentual values of incident Biodiesel cost tributes [13], deriving from several oilseeds;
⇨ impact of the percentual values in final customer Biodiesel prices [13], by subsequently applying progressive tribute discounts, aiming at achieving inferior prices relatively to the replaced fuel (that is, Diesel oil for scenario (A) and weighed gasoline "C" and alcohol for scenario (B), as per Attachment 2), considering several Biodiesel oilseeds;

- considering also the Attachment 2, the first step consists of evaluating the impact of all the Biodiesel incident tributes, of about 85% [13]; the discounts to be applied, by the brazilian government, in tributes, are in accordance with steps (1) to (5), described in the top half of Attachment 2):

(1) incidence of tributes: 29% of federal PIS/COFINS; 43% of state ICMS + MD (Distribution Margin) + L (Logistics) ; 13% to the customer [13];
(2) price with tributes = price without tributes x { 1 + [29% of PIS/COFINS (in refinery) + 43% (ICMS in Distribution + MD + L) + 13% (to the customer)] } [13];
(3) exemption of 100% of PIS/COFINS (federal tribute) to family agriculture, in Northern and North-Eastern regions, of palm and castor Biodiesel [27];
(4) exemption of 68% of PIS/COFINS (federal tribute) for general family agriculture [27];
(5) exemption of 32% of PIS/COFINS (federal tribute) for mechanized agriculture, in North and North-Eastern regions, of palm and castor Biodiesel [27].

- Following also Attachment 2, subsequent incident tribute discounts are applied, as per steps (a) to (g), as follows (in the bottom half of Attachment 2):

(a) value without tributes;

(b) value with tributes;
(c) value with 50% of ICMS + Distribution Margin + Logistics;
(d) value with 30% of ICMS + Distribution Margin + Logistics;
(e) value with 15% of ICMS + Distribution Margin + Logistics;
(f) value without ICMS + Distribution Margin + Logistics;
(g) value with only 13% to the customer

- as for Attachment 3, the calculation is based on the fastest achieved benefits, on a financial basis, to the government (government net income), via the followung steps for each oilseed (remark: Attachment 3 calculation is shown, based on scenario (A), but the same calculation is pursued for scenario (B)):
- step (A): Diesel oil cost, without tributes, which brazilian government will not pay, due to ts replacement by Biodiesel; in other words, this will become an income to the government;
- step (B): Diesel oil cost difference due to the tributes (income that the brazilian goverment will not receive);
- step (C): Biodiesel cost, to be covered by private sector (hyphothesis) and not by the government;
- step (D): Biodiesel: cost difference, due to the tributes (income which the government will receive);
- step (E): replacement of of government Gross income: (E) = (A) – (B) + (D);
- step (F): estimated investiment, in transestherification, when applicable to the government, of which gap is from R$ 0,40 / liter to R$ 0.50 / liter, with an average value of R$ 0.45 / liter of Biodiesel [21]
- step (G): government net income (R$/L)
- once Attachment s 2 and 3 calculations are made, net income calculation and employment number calculation, proporcionally divided by the volumes, are made, in Attachment 4, for each oilseed, via the following scenarios (remark: calculation sequence identified in Attachment 4):
- scenario (A): substitution of Diesel oil importation by Biodiesel, in 2008 (B2) and in 2013 (B5);
- scenario (B): introduction of Diesel oil/Biodiesel in light vehicles, in 2008 (with 5% of the light vehicles fleet, in 2008 and 15%, in 2013); similar calculation type, as per scenario (A).
- once Attachment 4 calculations are made, for scenarios (A) and (B), a composition of scenarios summary is pursued, for each region and technological route, focusing on government annual net income and on annual employment generation estimate, via Attachment 5, which also considers scenarios (A) / (B) , both isolatelly and in conjunction.

The Results Of The Sensitivity Analysis Indicate The Following:

- as per Attachment 2, palm, fried oil and cattle tallow are economically viable to the final customer, as they are cheaper than Diesel oil, for whatever tributation conditions;
- as per Attachment 2, the soybean is only viable to the final customer with total ICMS, Distribution Margfin and Logistics exemption, by applying 13% of margin to the final customer, under minimum, average and maximum value conditions, the later which with a slight deviation between Diesel oil and soybean Biodiesel;
- as per Attachment 2, castor os not economically viable, even by only applying 13% of margin to the final customer; therefore, the only way to viabilize it, to the customer, will be for the government to apply 67% of subsidy, aiming at becoming competitive relativelly to Diesel oil, under all minimum, average and maximum value conditions, to the final customer;
- by applying Attachment 3 for castor, 67% of government subsidy is necessary to viabilize the castor, but government unit net income will become negative, evn by destinating the transestherification investiment to the private sector;
- by applying Attachment 3 for castor, and bearing in mind the negative government unit net income, this will result in negative absolute income, if the reffered required volumes for the North-Eastern region are applied;
- by applying Attachment 4 model for all oilseeds, the required volumes for the brazilian regions (as per column (A)), particularly considering 2013 (B5), will be superior to fried oil offer (of 50 millions of liters a year) and cattle tallow (of 250 millions of liters a year) (Oliveira, 2004), except for the northern region, of which demand is about 190 millions of liters; therefore, the cattle tallow alternative will be considered only for the Northern region;
- by following Attachment 5 model, which also covers the scenarios (A) and (B) for all oilseeds, in scenarios 2a and 4a, the negtive impact of the castor income wll be compensated by the positive incomes from the ramaining oilseeds; the viable scenarios,both for pure Biodiesel oilseeds and for 2% additivated Biodiesel oilseeds, are as follows::
- financial focus, for 2008 and 2013: scenario 1a: maximum net income, to the goverment;
- social focus: cenário 2a, for 2008, and 4a, for 2013: maximum employment generation;

- technical and financial focus, for 2008 and 201313: scenario 5a: maximum net income, to the government;
- technical and social focus, for 2008 and 2013: scenario 6a: maximum employment generation;
- by following Attachment 5 model, for scenario (B), the negative impact of the castor net income, is not compensated by the positive net incomes from the remaining oilseeds, for scenarios 2b, 4b e 6b; the reason behind it is that the income decline, to the government, is due to the substitution of gasoline "C" plus alcohol tributes (Grupo Interministerial) by the corresponding Biodiesel tributes (Macedo, 2004), with less tributes incidence; therefore, the viable scenarios, both for pure Biodieseel oilseeds, and for 2% additivated Biodiesel olseeds, are as follows:
- financial focus, for 2008 and 2013: scenário 1b: maximum net income, to the govenment;
- lack of viability, regarding the social focus, for 2008 and 2013, of maximum employment generation, due to the negative government net income, according to scenarios 2b and 4b;
- technical and financial focus, for 2008 and 2013: scenario 5b: maximum net income, to the government;
- lack of vaibility, regarding the technical and social focus, for 2008 and 2013, of maximum employment generation, due to the negative govenment net income, according to scenario 6b;
- according to Attachment 5, the composition of scenarios (A) and (B), both for pure Biodiesel oilseeds and for 2% additivated Biodiesel oilseeds are:
- advantageous, regarding the financial focus, for 2008 and 2013: scenarios 1a + 1b: maximum net income, to the government;
- advantageous, regarding the technical and financial focus, for 2008 and 2013, for 2008 and 2013: scenarios 5a + 5b: maximum net income, to the government;
- disadvantageous, regarding the social focus, for 2008:: scenarios 2a + 2b: maximum employment generation;
- disadvantegous, regarding the social focus, for 2013: scenarios 4a + 4b: maximum employment generation;
- disadvantageous, regarding the technical and social focus, for 2008 and 2013: scenarios 6a + 6b: maximum employment generation.

X. ESTABLISHMENT OF A WORKPLAN, AIMING AT OVERCOMING THE SHORTFALLS OF THE BRAZILIAN BIODIESEL PROGRAM, WITH EMPHASIS ON UTILISATION ASPECTS

The following hyphothesis are being adopted for the proposal of this workplan, as previously described, in order to achieve maximum total net income, to the government::

- 13% of margin, to the final consumer, is applied for soybean, palm and cattle tallow, exempting all other tributes, in order to economically commonize and viabilize these criteria to the final customer, mainly the soybean;
- 67% of government subsidy is applied to castor, exempting all other tributes, in order to economically viabilize this product, to the final consumer;
- price variations relating to volume are not being considered;
- emissions level reduction benefits are not being considered;
- Diesel oil price variations relating to those of petrol barrel are not being considered;
- The following scenarios are being made, resulting from Attachments 3, 4 and 5, and according to the sensivity analysis of Biodiesel costs, as per Tables 3 and 4:

- s**cenario 1a + 1b, for 2008 (B2) and 2013 (B5): financial focus: maximum net income, to the government**, bearing in mind, the substitution of Diesel oil importation by Biodiesel, added to the introduction of Diesel oil / Biodiesel, in light vehicles; thus, the following vehicles will take part in this scenario:

⇨ **light passenger vehicles**, with injection systems of rotating pumps and electronic common rail systems;
⇨ **light commercial vehicles (pick-ups, minivans e mini-buses),** with injection systems of rotating pumps and electronic common rail systems;
⇨ **medium and heavy commercial vehicles (trucks),** with injection systems of alternate unit pumps and electronic common rail systems;
⇨ **medium and heavy commercial vehicles (buses and trucks),** with injection systems of unit injector pumps and electronic common rail systems;

- **scenario 5a + 5b, for 2008 (B2) and 2013 (B5): technical and financial focus: maximum net income, to the government**, with the same premises and vehicles previously adopted;

- **scenarios 2a, for 2008 (B2), and 4a, for 2013 (B5) : social focus: maximum employment generation**, bearing in mind, only the substitution of Diesel oil importation by Biodiesel; thus, the following vehicles willl take part in this scenario:
⇨ **light commercial vehicles (pick-ups, minivans and mini-buses),** with injection systems of rotating pumps and electronic common rail systems;
⇨ **medium and heavy commercial vehicles (trucks),** with injection systems of alternate unit pumps and electronic common rail systems;
⇨ **medium and heavy commercial vehicles (buses and trucks),** with injection systems of unit pumps and electronic systems;
- **scenario 6a, for 2008 (B2) and 2013 (B5): technical and social focus: maximum employment generation**, with the same premises and vehicles previously adopted

Inference proposal of parallel comparative validation tests, with Biodiesel B2 and Biodiesel B5, necessary to viabilize the Brazilian Biodiesel Program, for 2008 (B2) and 2013 (B5):

For each specific condition of each scenario identified above, the following inference of parallel comparative tests of Biodiesel B2 and Biodiesel B5 is suggested, as follows:

- **vehicle tests, controlled by monitored fleets, via the following conditions:**
- **preliminary analysis of two types of fuel, ona comparative simoutaneous basis (as per Attachment 6):**
⇨ fuels denominated "new", with 2% of additivation, of Biodiesel B2, according to Attachment 2, and of Biodiesel B5: it is necessary to stress that the Attachment 2 is valid for Biodiesel B2, as per Biodiesel Public Audience (Souza, 2004); nevertheless, bearing in mind the lacking of Biodiesel B5 specification, the same B2 specification, on na inference basis, will be applied to Biodiesel B5;
⇨ fuels denominated "old" B2 and B5, similar to the denominated "new" ones, except for storage timing period, ranging from 7 to 12 hours (that is, 100%, or twice as much the prescribed time as the original oxidation stability timing of until 6 hours), and except for the acidity index, above 0.8 mg/g, as per Attachment 2;

- **vehicle tests under the following conditions (with B2 and B5, on a comparative simoutaneous basis):**
⇨ new vehicles with "new" fuels;
⇨ used vehicles (with mileage as of 100 000 km) with "new" fuels;
⇨ new vehicles with "old" fuels;
⇨ used vehicles with "old" fuels;

- **for these simoutaneous and comparative vehicle tests, the following verifications, in every 25 000 km, are recommended:**
⇨ comparative values, by measurement and photographic visuallzation, of the admission and exhaust valves clearances and ingresses;
⇨ photographic visualization of injector pumps and fuel tanks, regarding cloggings, obstructions, leakings, saponifications and greased acids, besides fule injection pump pressure tests;
⇨ photographic visualization of oil and fuel filters, regarding cloggings, corrosions and deposits formation;
⇨ verification of lubricant oil consumption, dillution and contamination;
⇨ intervals of test verification for new vehicles: 0, 25 000, 50 000, 75 000 and 100 000 km;
⇨ intervals of test verifications for used vehicles: 100 000, 125 000, 150 000, 175 000 and 200 000 km;

- **estimated timing for the execution of these tests: 2 years;**
- **for these vehicle tests, Attachment 6 is recommended;**
-
- **engine dynamometer tests, under the following conditions (as per Attachment 7):**
- **preliminary analysis of fuel types, on a comparative simoutaneous basis, under the same previously described conditions relating to vehicle tests;**
- **pré-ignition and detonation tests, with B2 and B5, on a comparative simoutaneous basis, under the following conditions:**
⇨ new engines with "new" fuels;
⇨ new engines with "old" fuels;

- **for these simoutaneous and comparative engine dynamometer tests, of pré-ignition and detonation, the following verifications are recommended:**

⇨ comparative values, by auditive measurement, of pré-ignition and detonation during the test;
⇨ comparative tests of hot start (with B2 and B5), via engine temperature monitoring, compared to the corresponding values of Diesel oil;
⇨ comparative tests of cold start (with B2 and B5), via engine injection monitoring of timing and power, compared to the corresponding values of Diesel oil;

- **durability dinamometer tests, with B2 and B5, on a comparative simoutaneous basis, under the following conditions:**

⇨ new engines with "new" fuels;
⇨ new engines with "old" fuels;
⇨ estimated timing test of 2000 hours, with verification intervals of 100 hours;

- **for these simoutaneous and comparative engine dynamometer tests, of durability, the following verifications are recommended:**

⇨ continuous verification of torque, power and specific fuel consumption;
⇨ at every 100 hours, to proceed with photographic visualization of oil and fuel filters, ralating to cloggings, corrosions and deposit s formation;
⇨ at every 100 hours, to proceed with the verification of engine lubricating oil consumption, dillution and contamination;

- **estimated timing for the execution of these tests: 1 year;**
- **for these engine dynamometer tests, Attachment 7 is recommended.**

XI. FINAL CONSIDERATIONS

Due to the excessive tributation value over oilseeds used for Biodiesel production, mainly castor and soybean, it is urgently necessary to implement governmental tributes exemption and subsidies, as shown in this paper. The other shortfalls, like the technical, can be overcome, provided that Biodiesel prices be competitive compared to that of Diesel oil. Without this condition, there will be a final consumer lack of interest in buying Biodiesel, and will not benefit from the identified advantages. The elaboration of a workplan, aiming at identifying the shortfalls, and at establishing a workplan to overcome the shortfalls, on a technical-economic prospective, for the success of the Brazilian Biodiesel Program, has been achieved. Its is necessary to stress that, due to the complexity and the extension of Biodiesel subject, many simplifications were made, such as the non-mentioned aspects of emission reduction benefits, price variations relating to volumes, and the legal and logistic issues. Therefore, this paper aimed covering part of the whole problem, in order to suggest part of the solution.

Probably, this paper can be used as a reference, mainly for future developments, in order to mainly provide final customer with a greater accessibility of Biodiesel price to the final customer.

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Attachment 1 – Comparison of Diesel oil and Biodiesel specifications

CHARACTERISTIC	Unit	DIESEL OIL [Gov. Decree ANP 310/2001(1)	BIODIESEL USA [ASTM](2) D6751/02	BIODIESEL Europe (EN 14214)(3) Unit	BIODIESEL Europe (EN 14214)(3) Limit	BIODIESEL BRAZIL Gov. Decree ANP 255/2003(4)	BIODIESEL BRAZIL Gov. Decree ANP 042/2004(4)	BIODIESEL BRAZIL Suggestion Anfavea	BIODIESEL BRAZIL Proposal ANP XXX/2005	Alternative or addicional Proposal
APEARANCE										
Aspect	-	LII	NE	-	NE	LII	LII	Maintain	LII	LII
Color ASTM, máx.	-	3.0								
COMPOSITION										
Max. Iodine index (7)		NE	NE	-	120	Anotate	Annotate	Annotate	NE	NE
Max total Sulphur (7)	% mass	0.20 / 0.35	0.05	mg / Kg	10	0.001	Annotate	Alter to 0.001	0.05	0.001
Ester content (7)	% mass	NE	NE	% mass	96.5	NE	Annotate	96.5	NE	96.5
Max. Free Glycerine	% mass	NE	0.02	% mass	0.02	0.02	0.02	Agreeded	0.02	0.02
Max. Total Glycerine	% mass	NE	0.24	% mass	0.25	0.38	0.38	Alter to 0.25	0.38	0.25
Max. Methanol/ Ethanol	% mass	NE	NE	% mass	0.2	0.5	0.5	Alter to 0.20	0.5	0.2
Max.Monoglycerideous	% mass	NE	NE	% mass	0.8	1	Annotate	Agreeded	1	1
Max. Diglycerideous	% mass	NE	NE	% mass	0.2	0.25	Annotate	Agreeded	0.25	0.25
Max. Triglycerideous	% mass	NE	NE	% mass	0.2	0.25	Annotate	Agreeded	0.25	0.25
Max. Methylic Esther of Linonucleic Acid	-	-	-	% mass	12	NE	NE	-	NE	NE
Max. Poli-insaturated methylesther (4or more)	-	-	-	% mass	1	NE	NE	-	NE	NE
VOLATILITY										
Destilation										
50% recov. Volume, max	°C	245.0 - 310.0	NE	°C	NE	NE	NE	-	-	-
85% recov. Volume, max	°C	360.0 - 370.0	NE	°C	NE	NE	NE	-	-	-
90% recov. Volume, max	°C	NE	360	°C	NE	360	NE	Agreeded	360	360
95% recov. Volume, max	°C	NE	NE	°C	NE	NE	360	-	-	-
Density 15 C	kg/m³	NE	NE	kg/m³	860 to 900 (4)	NE	NE	-	-	-
Density 20 C	kg/m³	820 to 865 820 to 880	NE	kg/m³	NE	Annotate	Annotate	Agreeded	Annotate	Annotate
Flash Point	°C	38.0	130 min	°C	120	100	100	Alter to 120	100	100
FLUIDITY										
Viscosity at 40 C	mm²/s	2.5 to 5.5	1.9 to 6.0	mm²/s	3.5 to 5.0	Annotate	Annotate	Agreeded	Annotate	Annotate
Filter cold clogging point	°C	(5)	Annotate	°C	NE	(5)	(5)	Agreeded	(5)	(5)

CHARACTERISTIC	Unit	DIESEL OIL [Gov. Decree ANP 310/2001(1)	BIODIESEL USA [ASTM](2) D6751/02	BIODIESEL Europe (EN 14214)(3) Unit	BIODIESEL Europe (EN 14214)(3) Limit	BIODIESEL BRAZIL Gov. Decree ANP 255/2003(4)	BIODIESEL BRAZIL Gov. Decree ANP 042/2004(4)	BIODIESEL BRAZIL Suggestion Anfavea	BIODIESEL BRAZIL Proposal ANP XXX/2005	Alternative or addicional Proposal
COMBUSTION										
Min. Cetane number	-	42 (6)	47	-	51	45	Annotate	Agreeded	45	45
Max. Carbon residue	% mass	0.25	0.05	% mass	0.3	0.05	0.1	Agreeded	0.1	0.1
Max. Sulphur ashes	% mass	0.020	0.02	% mass	0.02	0.02	0.02	Agreeded	0.02	0.02
CORROSION										
Cooper corrosion 3h at 50 C, máx.	category class	1	3	category class	1	1	1	Agreeded	1	1
CONTAMINANTS										
Water / sediments, max	% volume	0.05	0.05	mg / Kg	500	0.05	0.05	Agreeded	0.05	0.05
Total contamination	mg / Kg	NE	NE	mg / Kg	24	NE	NE	24	Annotate	Annotate
Sodium+Potassium, max	mg / Kg	NE	NE	mg / Kg	5	10	10	Alter to 5	10	5
Calcium+Magnesium (7)	mg / Kg	NE	NE	mg / Kg	5	NE	Annotate	Alter to 5	NE	5
Phosphor, max. (7)	mg / Kg	NE	1	mg / Kg	10	10	Annotate	10	NE	10
Acidity index	mgKOH/g	NE	0.8	mgKOH/g	0.5	0.8	0.8	Alter to 0.5	0.8	0.5
STABILITY										
Oxidation stability at 110 C, mín.	h	NE	NE	h	6	6	6	Agreeded	6	6

(1) Governmental Decree ANP 310/2001 altered by Resolution ANP 36/2004 - Óleo Diesel B Type (interior) and D (metropolitan).

(2) American specification - ASTM D6751/02

(3) Temporary European specification

(4) Measured at 15 C.

(5) Limits as per chart in Governmental Decree ANP 310 / 2001.

(6) Alternatively for Cetane Number, the Cetane Index is allowed.

(7) Non - obligatory analysis for all commercialized boat-loads. One compulsory sample, for every three months, for each producer (for ANP databank)

Attachment 2 – Substitution of Diesel oil importation by Biodiesel: Sensitivity analysis of Biodiesel prices, compared to that of Diesel oil (R$/L)

Percentage values of incident tributes in Biodiesel costs

	Diesel Oil		Northern Region - Palm (Ethylic) (5) Mecanizado		Northern Region - Palm (Ethylic) (3) Familiar		North-Eastern Region - Castor (Methylic) (5) Mecanizado		North-Eastern Region - Castor (Methylic) (3) Familiar	
	Partial	Total	Partial	Total	Partial	Total	Partial	Total	Partial	Total
Without tributes (1)	0	0	0	0	0	0	0	0	0	0
Refinery (1)	29	29	20	20	0	0	20	20	0	0
Distributor (1)	43	72	43	63	43	43	43	63	43	43
Customer (1)	13	85	13	76	13	56	13	76	13	56

	Fried Oil Mec (Ethylic)		Cattle Tallow Mec (Ethylic)		Fried Oil Mec (Methylic)		Cattle Tallow Mec (Methylic)	
	Partial	Total	Partial	Total	Partial	Total	Partial	Total
Without tributes (1)	0	0	0	0	0	0	0	0
Refinery (1)	29	29	29	29	29	29	29	29
Distributor (1)	43	72	43	72	43	72	43	72
Customer (1)	13	85	13	85	13	85	13	85

Impact of percentage values of tributes in Biodiesel customer final prices (R$/L)

	Diesel Oil			Northern Region - Palm (Ethylic) Mechanized (5)			Northern Region - Palm (Ethylic) Family (3)			North-Eastern Region - Castor (Methylic) Mechanized (5)			North-Eastern Region - Castor (Methylic) Family (3)			South-Eastern Central-Western Soybean (Ethylic) Mechanized		
	Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average
Without tributes	0,74	0,76	0,75	0,04	0,23	0,14	0,04	0,23	0,14	0,9	2,21	1,59	0,9	2,20	1,59	0,54	1,4	0,97
With tributes (2)	1,369	1,406	1,3875	0,0704	0,4048	0,2464	0,0624	0,3584	0,2104	1,584	4,0121	2,7904	1,404	3,5564	2,4104	0,999	2,59	1,7945
W/5%: ICMS+MD+L				0,0616	0,3542	0,2054	0,0536	0,3402	0,1976	1,384	3,5912	2,4404	1,206	3,0652	2,1346	0,8882	2,212	1,5155
W/3%: ICMS+MD+L				0,0504	0,3381	0,2044	0,0504	0,2990	0,1764	1,314	3,3201	2,3204	1,134	2,8720	2,0034	0,8316	2,156	1,4934
W/15%: ICMS+MD+L				0,0556	0,3197	0,1946	0,0476	0,2737	0,1646	1,251	3,1642	2,2081	1,071	2,7522	1,9621	0,7482	2,072	1,4356
Without ICMS+MD+L				0,0532	0,3059	0,1862	0,0452	0,2599	0,1582	1,107	2,6324	2,1047	1,107	2,5764	1,7967	0,7663	1,809	1,3774
With 13% customer				0,0452	0,2599	0,1582	0,0452	0,2599	0,1582	1,017	2,5764	1,7967	1,107	2,5764	1,7967	0,6102	1,582	1,0961

	Fried Oil Mec (Ethylic)			Cattle Tallow Mec (Ethylic)			Fried Oil Mec (Methylic)			Cattle Tallow Mec (Methylic)			South-Eastern Central-Western Soybean (Ethylic) Mechanized		
	Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average
Without tributes	0,2	0,59	0,39	0,23	0,79	0,54	0,16	0,51	0,34	0,25	0,71	0,48	0,5	1,33	0,92
With tributes (2)	0,37	1,0915	0,7215	0,518	1,4615	0,999	0,296	0,9435	0,629	0,4625	1,3135	0,888	0,925	2,4605	1,702
W/5%: ICMS+MD+L	0,326	0,9617	0,6357	0,4564	1,2877	0,8802	0,2608	0,8313	0,5542	0,4075	1,1573	0,7824	0,815	2,1679	1,4996
W/3%: ICMS+MD+L	0,308	0,9086	0,6006	0,4312	1,2166	0,8316	0,2464	0,7854	0,5236	0,385	1,0934	0,7392	0,77	2,0482	1,4168
W/15%: ICMS+MD+L	0,74	1,4604	1,2616	0,4144	1,1692	0,7992	0,2343	0,7541	0,5002	0,37	1,0501	0,7084	0,74	1,9684	1,3616
Without ICMS+MD+L	0,214	0,6379	0,5534	0,3976	1,1218	0,7668	0,2272	0,7242	0,4821	0,355	1,0082	0,6816	0,71	1,8886	1,2994
With 13% customer	0,226	0,6667	0,4407	0,2164	0,8927	0,6102	0,1808	0,5763	0,3842	0,2825	0,8023	0,5424	0,565	1,5029	1,1096

Remarks:

(1) Incidence of tributes: 29% of PIS/COFINS (federal tributes); 43% [ICMS (state tributes) + MD (Distributor Margin) + L (Logistics)]; 13% to the customer

(2) Price with tributes = Price without tributes x [1 + [29% PIS + COFINS (in Refinery) + 43% (ICMS in Distributor + MD + L) + 13% (to the Customer)]]

(3) 100% exemption of PIS/COFINS (federal tributes) for family agriculture, in Northern and North-Eastern regions, for palm and castor

(4) 68% exemption of PIS/COFINS (federal tributes) for general family agriculture

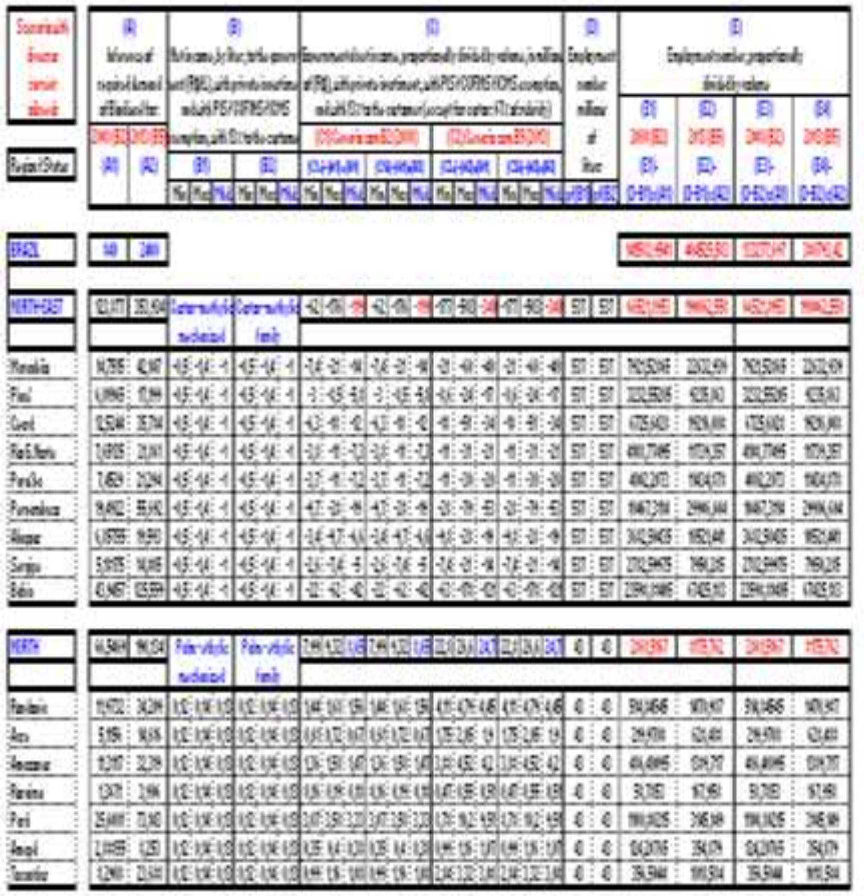
(5) 32% exemption of PIS/COFINS (federal tributes) for mechanized agriculture, in Northern and North-Eastern regions, for palm and castor

Attachment 3 – Substitution of Diesel oil importation by Biodiesel: final prices impact, of the substitution of Diesel oil importation, by Biodiesel fabrication, in governmental net income (R$/L)

(1) Northern Region - Palm - mechanized ethylic route

	(A) Diesel cost to the government			(B) Diesel differential costs due to the tributes			(C) Biodiesel costs			(D) Biodiesel differential costs due to the tributes			(E)=(A)-(B)+(D) Substitution of gross income to the government			(F) Estimated investment in transesterification by the government			(F) Estimated investment in transesterification by the private sector			(G1)=(E)-(F) Net income to the government with gov. investment			(G2)=(E) Net income to the government without gov. investment			(G3)=(G1+G2)/2 Net income to the government 50% gov. / 50% private		
	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
Without tributes	0,74	0,76	0,75	0,62	0,68	0,64	0,04	0,22	0,14	0	0	0	0,11	0,11	0,11	0,4	0,5	0,45	0,4	0,5	0,45	-0,3	-0,4	-0,3	0,11	0,11	0,11	-0,1	-0,1	-0,1
With tributes	1,37	1,41	1,39				0,07	0,4	0,25	0,03	0,17	0,11	0,14	0,29	0,22	0,4	0,5	0,45	0,4	0,5	0,45	-0,3	-0,2	-0,2	0,14	0,29	0,22	-0,1	0,04	-0
W/5%: ICMS+MD+L							0,06	0,35	0,22	0,02	0,12	0,08	0,13	0,24	0,19	0,4	0,5	0,45	0,4	0,5	0,45	-0,3	-0,3	-0,3	0,13	0,24	0,19	-0,1	-0	-0
W/3%: ICMS+MD+L							0,06	0,34	0,2	0,02	0,11	0,06	0,13	0,22	0,18	0,4	0,5	0,45	0,4	0,5	0,45	-0,3	-0,3	-0,3	0,13	0,22	0,18	-0,1	-0	-0
W/15%: ICMS+MD+L							0,06	0,32	0,19	0,02	0,09	0,05	0,13	0,2	0,17	0,4	0,5	0,45	0,4	0,5	0,45	-0,3	-0,3	-0,3	0,13	0,2	0,17	-0,1	-0	-0,1
Without ICMS+MD+L							0,05	0,31	0,19	0,01	0,08	0,05	0,12	0,19	0,16	0,4	0,5	0,45	0,4	0,5	0,45	-0,3	-0,3	-0,3	0,12	0,19	0,16	-0,1	-0,1	-0,1
With 13% customer							0,05	0,26	0,16	0,01	0,03	0,02	0,12	0,14	0,13	0,4	0,5	0,45	0,4	0,5	0,45	-0,3	-0,4	-0,3	0,12	0,14	0,13	-0,1	-0,1	-0,1

Attachment 4 – Substitution of Diesel oil importation by Biodiesel: calculation of governmental net income and employment generation, proportionally divided by volume, in the Brazilian Biodiesel Program



Attachment 5 – Composition and combination of scenarios of substitution of Diesel importation by Biodiesel and the introduction of Diesel/Biodiesel in light vehicles: scenarios of governmental net income and employment generation, relating to mixture levels (identification of the most viable advantageous scenarios):
Scenario (A): substitution of Diesel oil importation by Biodiesel;
Scenario (B): introduction of Diesel Oil / Biodiesel inlight vehicles;
Scenario (C): composition of scenarios (A) and (B)

SCENARIO 1a+1b

Financial focus: maximum net income
Valid for marginal variations of 2% additivation in the oilseed

Region	Technological route	Governmental net income (in millions of R$)		Estimated employment generation	
		B2 (2008)	B5 (2013)	B2 (2008)	B5 (2013)
Northeast	Soybean ethylic - mechanized	30,2	89,21	14435	43743
North	Cattle Tallow ethylic - mechanized	12,15	35,45	1029	3119
Central West	Soybean ethylic - mechanized	24,2	71,45	11557	35032
Southeast	Soybean ethylic - mechanized	90,1	265,9	43005	130320
South	Soybean ethylic - mechanized	41,69	122,94	19892	60282
	TOTAL	198,34	584,95	89918	272496

SCENARIO 2a

Social focus: maximum employment generation in 2008
Valid for marginal variations of 2% additivation in the oilseed

Region	Technological route	Governmental net income (in millions of R$)		Estimated employment generation	
		B2 (2008)	B5 (2013)	B2 (2008)	B5 (2013)
Northeast	Castor - methylic subsidy of 67%	-119	-340	66521	190062
North	Cattle Tallow ethylic - mechanized	12	34,2	998	2852
Central West	Soybean ethylic - mechanized	23,8	68	11207	32021
Southeast	Soybean ethylic - mechanized	88,6	253	41702	119150
South	Soybean ethylic - mechanized	41	117	19290	55115
	TOTAL	46,4	132,2	139718	399200

SCENARIO 4a

Social focus: maximum employment generation in 2013
Shortfall availability, for Cattle Tallow, in 2008

Region	Technological route	Governmental net income (in millions of R$)		Estimated employment generation	
		B2 (2008)	B5 (2013)	B2 (2008)	B5 (2013)
Northeast	Castor - methylic subsidy of 67%	-119	-340	66521	190062
North	Dendê etílico - mecanizado	8,65	24,7	2861	8175
Central West	Soybean ethylic - mechanized	23,8	68	11207	32021
Southeast	Soybean ethylic - mechanized	88,6	253	41702	119150
South	Soybean ethylic - mechanized	41	117	19290	55115
	TOTAL	43,05	122,7	141581	404523

SCENARIO 5a+5b

Technical and financial focus: maximum net income
Methanol technically better than ethanol, and valid for marginal variations of 2% additivation in the oilseed

Region	Technological route	Governmental net income (in millions of R$)		Estimated employment generation	
		B2 (2008)	B5 (2013)	B2 (2008)	B5 (2013)
Northeast	Soybean ethylic - mechanized	28,86	85,38	12774	38711
North	Cattle Tallow ethylic - mechanized	10,72	31,47	137	415
Central West	Soybean ethylic - mechanized	23,17	68,39	10227	30993
Southeast	Soybean ethylic - mechanized	86,28	254,9	38058	115329
South	Soybean ethylic - mechanized	39,84	117,49	17604	53346
	TOTAL	189,07	557,63	78800	238794

	SCENARIO 6a	Technical and social focus: maximum employment generation Methanol technically better than ethanol, and valid for marginal variations of 2% additivation in the oilseed			
	Technological route	Governmental net income (in millions of R$)		Estimated employment generation	
		B2 (2008)	B5 (2013)	B2 (2008)	B5 (2013)
Northeast	Castor - methylic subsidy of 67%	-119	-340	66521	190062
North	Cattle Tallow ethylic - mechanized	10,6	30,4	133	380
Central West	Soybean ethylic - mechanized	22,8	65,2	9918	28337
Southeast	Soybean ethylic - mechanized	84,9	243	36905	105443
South	Soybean ethylic - mechanized	39,3	112	17071	48774
	TOTAL	38,6	110,6	130548	372996

Attachment 6 – Vehicle comparative validation tests, with Biodiesel B2 and B5, necessary to viabilize the Brazilian Biodiesel Program.

Conditions "C" of testing: (C I) , (C II) , (C III) or (C IV):
(C I): New vehicle / "New" fuel (C II): New vehicle / "Old" fuel (C III): Used vehicle / "New" fuel (C IV): Used vehicle / "Old" fuel

Biodiesel B2 (2008)
Biodiesel B5 (2013)
Scenario identification:
Oilseed / technological route identification:

Vehicle identification v.c.: vehicle category p.t.: injection pump type [(i.s.: injection system: electronic common rail (e.c.r.)]	0 km (C I) 0 km (C II) 100 000 km (C III) 100 000 km (C IV)	25 000 km (C I) 25 000 km (C II) 125 000 km (C III) 125 000 km (C IV)	50 000 km (C I) 50 000 km (C II) 150 000 km (C III) 150 000 km (C IV)	75 000 km (C I) 75 000 km (C II) 175 000 km (C III) 175 000 km (C IV)	100 000 km (C I) 100 000 km (C II) 200 000 km (C III) 200 000 km (C IV)
	Valves: maximum obtained values of: Clearances (Adm, Exh); Housing ingress (Adm, Exh)	Valves: maximum obtained values of: Clearances (Adm, Exh); Housing ingress (Adm, Exh); Oil consumption	Valves: maximum obtained values of: Clearances (Adm, Exh); Housing ingress (Adm, Exh); Oil consumption	Valves: maximum obtained values of: Clearances (Adm, Exh); Housing ingress (Adm, Exh); Oil consumption	Valves: maximum obtained values of: Clearances (Adm, Exh); Housing ingress (Adm, Exh); Oil consumption
v.c.: light passenger [valid only for scenarios (1a+1b) and (5a+5b)] p.t.: rotating (e.c.r.)					
v.c.: light commercial (pick-ups, minivans e mini-buses) p.t.: rotating (e.c.r.)					
v.c.: medium and heavy commercial (trucks) p.t.: "unit pump" (e.c.r.)					
v.c.: medium and heavy commercial (buses and trucks) p.t.: "unit injector" (e.c.r.)					

Number of necessary vehicles to perform each scenario:
(1a+1b): financial focus (2008 / 2013): max. net income (2 oilseeds): 64
(5a+5b): technical / financial focus (2008/2013): max. net income (idem): 64
(2a): social focus (2008): max. employment generation (3 oilseeds): 72
(4a): social focus (2013): max. employment generation (idem): 72
(6a): technical / social focus (2008/2013): max. employment gen. (idem): 72
Estimated timing period for the execution of these tests : 2 years

Photographic diagnosis codification of components:
A: acidity of fuel
C: clogging
CR: corrosion
DE: deposits
DI: dilution
F: fracture
GA: greased acids
NR: no remarks
P: polimerization
S: saponification

	25 000 km (C I) 25 000 km (C II) 125 000 km (C III) 125 000 km (C IV)	50 000 km (C I) 50 000 km (C II) 150 000 km (C III) 150 000 km (C IV)	75 000 km (C I) 75 000 km (C II) 175 000 km (C III) 175 000 km (C IV)	100 000 km (C I) 100 000 km (C II) 200 000 km (C III) 200 000 km (C IV)
	Photographic diagnosis of components: Injection pump; Fuel tank; Filters of: Oil, Air, Fuel	Photographic diagnosis of components: Injection pump; Fuel tank; Filters of: Oil, Air, Fuel	Photographic diagnosis of components: Injection pump; Fuel tank; Filters of: Oil, Air, Fuel	Photographic diagnosis of components: Injection pump; Fuel tank; Filters of: Oil, Air, Fuel
v.c.: light passenger [valid only for scenarios (1a+1b) and (5a+5b)] p.t.: rotating (e.c.r.)				
v.c.: light commercial (pick-ups, minivans and mini-buses) p.t.: rotating				
v.c.: medium and heavy commercial (trucks) p.t.: "unit pump" (e.c.r.)				
v.c.: medium and heavy commercial (buses and trucks) p.t.: "unit injector" (e.c.r.)				

Attachment 7: Dynamometer comparative validation tests, with Biodiesel B2 and B5, necessary to viabilize the Brazilian Biodiesel Program.

Conditions "C" of testing: (C-V) or (C-VI):
(C-V): New engine / "New" fuel (C-VI): New engine / "Old" fuel

Biodiesel B2 (2008)
Biodiesel B5 (2013)
Scenario identification
Identification of utilized / technological route

Vehicle identification n.c.: vehicle category p.t.: injection pump type [(i.s.: inj. system: electr. common rail (e.c.r.)]	Maximum values of		Min. fuel spec. cons.	Photographic diagnosis of components			Maximum values of		Min. fuel spec. cons.	Photographic diagnosis of components			Maximum values of		Min. fuel spec. cons.	Photographic diagnosis of components			Maximum values of		Min. fuel spec. cons.	Photographic diagnosis of components			Maximum values of		Min. fuel spec. cons.	Photographic diagnosis of components		
	Torque	Power	spec. cons.	Filters of Oil	Air	Fuel	Torque	Power	spec. cons.	Filters of Oil	Air	Fuel	Torque	Power	spec. cons.	Filters of Oil	Air	Fuel	Torque	Power	spec. cons.	Filters of Oil	Air	Fuel	Torque	Power	spec. cons.	Filters of Oil	Air	Fuel
n.c.: light passenger [valid only for scenarios (1a+1b) and (5a+5b)] p.t.: rotating (e.c.r.)																														
n.c.: light commercial (pick-ups, minivans and mini-buses) p.t.: rotating (e.c.r.)																														
n.c.: medium and heavy commercial (trucks) p.t.: "unit pump" (e.c.r.)																														
n.c.: medium and heavy commercial (buses and trucks) p.t.: "unit injector" (e.c.r.)																														

Number of necessary engines to perform each scenario:

(1a+1b): financial focus (2008 / 2013): maximum net income (2 allowed):	32
(5a+5b): technical / financial focus (2008 / 2013): maximum net income (idem):	32
(2a): social focus (2008): maximum employment generation (3 allowed):	36
(4a): social focus (2013): maximum employment generation (idem):	36
(6a): technical / social focus (2008 / 2013): maximum employment generation (ibidem):	36

Estimated timing period for the execution of these tests : 1 year

Photographic diagnosis codification of components:
A: acidity of fuel
C: clogging
CR: corrosion
DE: deposits
DI: dilution
F: fracture
GA: greased acids
NR: no remarks
P: polimerization
S: saponification

Detonation level:
L: light
M: medium
H: high

	B2 Calibration conditions for Biodiesel B2					B5 Calibration conditions for Biodiesel B5				
	Pre-ignition (L) (M) (H)	Detonation (L) (M) (H)	Start-up conditions: Cold injection: Injection timing	Injection power	Hot Engine temperature	Pre-ignition (L) (M) (H)	Detonation (L) (M) (H)	Start-up conditions: Cold injection: Injection timing	Injection power	Hot Engine temperature
n.c.: light passenger [valid only for scenarios (1a+1b) and (5a+5b)] p.t.: rotating (e.c.r.)										
n.c.: light commercial (pick-ups, minivans and mini-buses) p.t.: rotating										
n.c.: medium and heavy commercial (trucks) p.t.: "unit pump" (e.c.r.)										
n.c.: medium and heavy commercial (buses and trucks) p.t.: "unit injector" (e.c.r.)										