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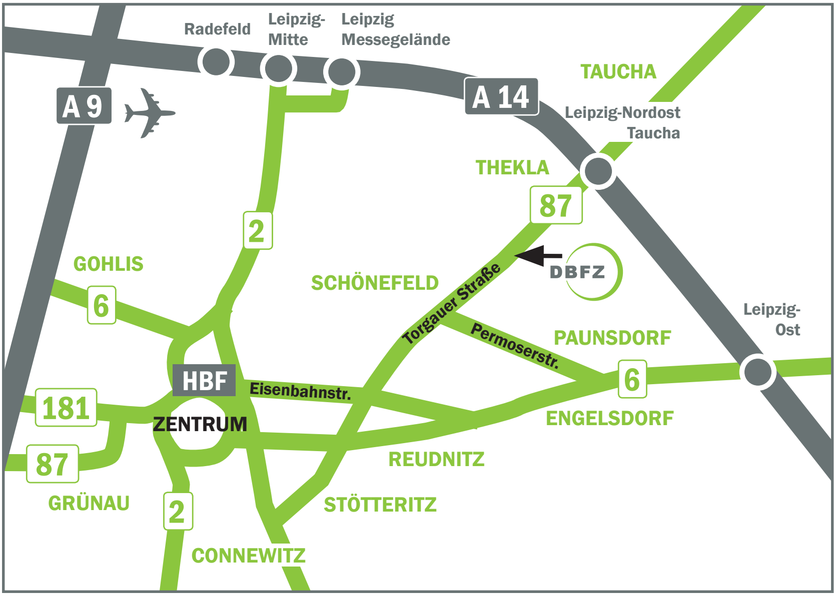
# Politics and Economics of Ethanol and Biodiesel Production and Consumption in Brazil

Jens Giersdorf

# Imprint / Approach

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## Approach

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# Politics and Economics of Ethanol and Biodiesel Production and Consumption in Brazil

**Inauguraldissertation**
zur Erlangung des Grades eines
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# Abbreviations

Table 1 – Abbreviations

| Abbreviation | Explanation |
|---|---|
| AIAA | Associação das Indústrias de Açúcar e Álcool do Estado de São Paulo (Association of the Sugar and Alcohol Industries of the State of São Paulo) |
| ANFAVEA | Associação Nacional dos Fabricantes de Veículos Automotores (National Association of the Car Manufacturers) |
| ANP | Agência Nacional do Petróleo, Gás Natural e Biocombustíveis (National Agency for Petroleum, Natural Gas and Biofuels) |
| APEX-Brasil | Agência Brasileira de Promoção de Exportações e Investimentos (Brazilian Agency for Export and Investment Promotion) |
| BB | Banco do Brasil |
| BC | Banco Central (Central Bank) |
| bn | Billion |
| BNDES | Banco Nacional de Desenvolvimento Econômico e Social (National Bank for Economic and Social Development) |
| BNE | Banco do Nordeste |
| BRL | Brazilian Real |
| CAFTA-DR | Dominican Republic-Central America Free Trade Agreement |
| CDE | Conselho de Desenvolvimento Econômico (Council for Economic Development) |
| CEIB | Comissão Executiva Interministerial (Interministerial Executive Commission) |
| CENAL | Comissão Executiva Nacional do Álcool (National Executive Commission for Alcohol) |
| CETEC | Fundação Centro Tecnológico de Minas Gerais (Foundation Technological Centre of Minas Gerais) |
| CGEE | Centro de Gestão e Estudos Estratégicos (Center for Strategic Studies and Management) |
| CIMA | Conselho Interministerial do Açúcar e do Álcool (Interdepartmental Council for Sugar and Alcohol) |
| CINAL | Comissão Interministerial do Álcool (Interdepartmental Commission for Alcohol) |
| CMN | Conselho Monetário Nacional (National Monetary Council) |
| CNAL | Comissão Nacional do Álcool (National Commission for Alcohol) |
| CNP | Conselho Nacional de Petróleo (National Petroleum Council) |
| CNPE | Conselho Nacional de Política Energética (National Council for the Energy Policy) |
| CNPEM | Centro de Pesquisa em Energia e Materiais (Energy and Material Research Centre) |

| | |
|---|---|
| CNPq | Conselho Nacional de Desenvolvimento Científico e Tecnológico (National Council of Technological and Scientific Development) |
| CONAMA | Conselho Nacional do Meio Ambiente (National Council for the Environment) |
| CONSECANA | Conselho dos Produtores de Cana-de-Açúcar, Açúcar e Álcool do Estado de São Paulo (Council of the Sugarcane, Sugar and Ethanol producers of the state of São Paulo) |
| CONTAG | Confederação Nacional dos Trabalhadores na Agricultura (National Confederation of the Agricultural Workers) |
| COPERSUCAR | Cooperativa Central dos Produtores de Açúcar e Álcool do Estado de São Paulo (Cooperative of the Sugar and Alcohol Producers of the State of São Paulo) |
| COPLACANA | Cooperativa dos Plantadores de Cana do Estado de São Paulo (Cooperative of the Cane Growers of the State of São Paulo) |
| CPT | Comissão Pastoral da Terra (Pastoral Land Commission) |
| CTA | Centro Técnico Aeroespacial (Research Institute of the Air Force) |
| CTBE | Centro de Ciência e Tecnologia do Bioetanol (Ethanol Science and Technology Centre) |
| CTC | Centro de Tecnologia Canavieira (Centre for Sugarcane Technology) |
| CUT | Central Única dos Trabalhadores (Unified Workers' Central) |
| DNC | Departamento Nacional de Combustíveis (National Department for Biofuels) |
| EMBRAPA | Empresa Brasileira de Pesquisa Agropecuária (Brazilian Agricultural Research Corporation) |
| EPA | United States Environmental Protection Agency |
| ESALQ-USP | Escola Superior de Agricultura "Luiz de Queiroz"- Universidade de São Paulo (Luiz de Queiroz College of Agriculture - University of São Paulo) |
| FAPESP | Fundação de Amparo à Pesquisa do Estado de São Paulo (São Paulo Research Foundation) |
| FCO | Fundo Constitucional de Financiamento do Centro-Oeste (Constitutional Fund for the Financing of the Centre-West) |
| FE | Fuel equivalent |
| FETRAF | Federação dos Trabalhadores na Agricultura Familiar (Federation of the Small Farmers) |
| FFV | Flexible-fuel vehicle |
| FINEP | Financiadora de Estudos e Projetos (Financing Agency of Studies and Projects) |
| FME | Fundo de Mobilização Energética (Energy Mobilization Fund) |
| FNDCT | Fundo Nacional de Desenvolvimento Científico e Tecnológico (National Fund for the Scientific and Technological Development) |
| FNE | Fundo Constitucional de Financiamento do Nordeste (Constitutioal Fund for the Financing of the Northeast) |
| FNO | Fundo Constitucional de Financiamento do Norte (Constitutional Fund for the Financing of the North) |

| | |
|---|---|
| FUNDECI | Fundo de Desenvolvimento Científico e Tecnológico (Fund for Scientific and Technological Development) |
| GHG | Greenhouse Gases |
| IAA | Instituto de Açúcar e Álcool (Sugar and Alcohol Institute) |
| ICMS | Imposto sobre Circulação de Mercadoria e de Serviços (Tax on the Circulation of Goods and Services) |
| INCRA | Instituto Nacional de Colonização e Reforma Agrária (National Institute for the Colonisation and the Agrarian Reform) |
| INMETRO | Instituto Nacional de Metrologia, Normalização e Qualidade Industrial (National Institute for Metrology, Standardization and Industrial Quality) |
| IPI | Imposto de Produtos Industrializados (Tax on industrialised products) |
| kg | Kilogram |
| l | Litres |
| lb | Pound |
| LCA | Lyfe Cycle Assessment |
| m | Million |
| MAPA | Ministério da Agricultura, Pecuária e Abastecimento (Ministry of Agriculture, Livestock and Food Supply) |
| MCidades | Ministério das Cidades (Ministry of Cities) |
| MCT | Ministério da Ciência e Tecnologia (Ministry of Science and Technology) |
| MDA | Ministério do Desenvolvimento Agrário (Ministry of Agrarian Development) |
| MDIC | Ministério do Desenvolvimento, Indústria e Comércio Exterior (Ministry of Development, Industry and External Trade) |
| MF | Ministério da Fazenda (Ministry of Finance) |
| MIC | Ministério de Indústria e Comércio (Ministry of Industry and Commerce) |
| MICT | Ministério da Indústria, do Comércio e do Turismo (Ministry of Industry, Commerce and Tourism) |
| MIN | Ministério de Integração Nacional (Ministry of National Integration) |
| Mio | Million |
| MMA | Ministério do Meio Ambiente, dos Recursos Hídricos e da Amazônia Legal (Ministry of Environment, Water Resources and Legal Amazon) |
| MME | Ministério de Minas e Energia (Ministry of Mining and Energy) |
| MP | Ministério do Planejamento, Orçamento e Gestão (Ministry of Planning, Budget and Management) |
| MST | Movimento dos Trabalhadores Rurais Sem Terra (Movement of the Landless Rural Workers) |
| MSTR | Movimento Sindical dos Trabalhadores Rurais (Union Movement of the Rural Workers) |

| | |
|---|---|
| ORPLANA | Organização dos Plantadores de Cana da Região Centro-Sul do Brasil (Organisation of the Sugarcane Growers of the Centre-South region of Brazil) |
| OVEG | Programa Nacional de Energia de Óleos Vegetais (National Programme of Vegetable Oil Energy) |
| p.a. | per annum |
| PAC | Programa de Aceleração do Crescimento (Programme for the Acceleration of the Growth) |
| PL | Projeto de Lei (Bill) |
| PMDB | Partido do Movimento Democrático Brasileiro (Brazilian Democratic Movement Party) |
| PME | Programa de Mobilização Energética (Energy Mobilization Programme) |
| PNPB | Programa Nacional de Produção e Uso de Biodiesel (National Programme for the Production and Use of Biodiesel) |
| PNRA | Programa Nacional de Reforma Agrária (National Programme for Agrarian Reform) |
| PROÁLCOOL | Programa Nacional do Álcool (National Alcohol Programme) |
| PROBIODIESEL | Programa Brasileiro de Desenvolvimento Tecnológico de Biodiesel (Brazilian Programme for the Technological Development of Biodiesel) |
| PRONAF | Programa Nacional de Fortalecimento da Agricultura Familiar (National Programme for the Strengthening of the Small Farmer Agriculture) |
| PROÓLEO | Programa Nacional de Produção de Óleos Vegetais para Fins Energéticos (National Programme for the Production of Vegetable Oils for Energetic Use) |
| PSDB | Partido da Social Democracia Brasileira (Brazilian Social Democratic Party) |
| PT | Partido dos Trabalhadores (Workers' Party) |
| RBTB | Rede Brasileira de Tecnologia de Biodiesel (Brazilian Biodiesel Technology Network) |
| RFS | Renewable Fuel Standard |
| RIDESA | Rede Interuniversitária para o Desenvolvimento Sucroalcooleiro (Interuniversitarian Network for the Development of the Sugar and Ethanol Sector) |
| SELIC | Sistema Especial de Liquidação e de Custódia (Special System of Clearance and Custody) |
| SEPLAN | Secretaria de Planejamento (National Planning Secretariat) |
| SINDACÚCAR | Sindicato da Indústria do Açúcar e do Álcool no Estado de Pernambuco (Syndicate of the Sugar and Alcohol Industry in the state of Pernambuco) |
| SINDICOM | Sindicato Nacional das Empresas Distribuidoras de Combustíveis e de Lubrificantes (National Association of the Fuel and Lubricant Distribution Companies) |
| STI | Secretaria de Tecnologia Industrial (Secretariat of Industrial Technology) |
| t | Tons |
| TJLP | Taxa de Juros de Longo Prazo (Long term interest rate) |
| TRS | Theoretically Recoverable Sucrose |

| | |
|---|---|
| UFCE | Universidade Federal do Ceará (Federal University of Ceará) |
| UFPR | Universidade Federal do Paraná (Federal University of Paraná) |
| UNICA | União da Indústria de Cana-de-Açúcar (Union of the Sugarcane Industry) |
| UNICAMP | Universidade Estadual de Campinas (State University of Campinas) |
| USD | US-Dollar |
| WTO | World Trade Organization |
| WWF | World Wide Fund for Nature |

## Brazilian states and regions


Figure 1 – Map of Brazilian states and regions (Instituto Brasileiro de Geografia e Estatística 2010a)

Table 2 – Brazilian states by alphabetical order

| Abbreviation | State |
|---|---|
| AC | Acre |
| AL | Alagoas |
| AP | Amapá |
| AM | Amazonas |
| BA | Bahia |
| CE | Ceará |
| DF | Distrito Federal |
| ES | Espírito Santo |
| GO | Goiás |
| MA | Maranhão |
| MT | Mato Grosso |
| MS | Mato Grosso do Sul |
| MG | Minas Gerais |
| PA | Pará |
| PB | Paraíba |
| PR | Paraná |
| PE | Pernambuco |
| PI | Piauí |
| RJ | Rio de Janeiro |
| RN | Rio Grande do Norte |
| RS | Rio Grande do Sul |
| RO | Rondônia |
| RR | Roraima |
| SC | Santa Catarina |
| SP | São Paulo |
| SE | Sergipe |
| TO | Tocantins |

# General data

Table 3 – Currency exchange rates 2004-2010 (OANDA 2010)

| Year | BRL/USD | BRL/EUR | EUR/USD |
|---|---|---|---|
| 2004 | 2.93 | 3.63 | 1.24 |
| 2005 | 2.43 | 3.04 | 1.25 |
| 2006 | 2.18 | 2.73 | 1.26 |
| 2007 | 1.95 | 2.66 | 1.37 |
| 2008 | 1.84 | 2.67 | 1.47 |
| 2009 | 2.00 | 2.76 | 1.39 |
| 2010 | 1.69 | 2.33 | 1.32 |

Table 4 – Energy content of ethanol and gasoline fuel (Schmitz, Henke and Klepper 2009)

| Fuel | MJ/litre |
|---|---|
| Gasoline | 32.6 |
| Ethanol | 21.2 |
| Gasolina C (75% Gasoline, 25% Ethanol) | 29.7 |
| Gasolina C (80% Gasoline, 20% Ethanol) | 30.3 |
| Relation Ethanol to Gasolina C used in calculations | 70% |

Table 5 – Energy content of biodiesel and diesel fuel (Schmitz, Henke and Klepper 2009)

| Fuel | MJ/litre |
|---|---|
| Diesel | 36.1 |
| Biodiesel | 32.6-36.08 |

Table 6 – Characteristic values of diesel fuel and selected fatty acid methyl esters (Santos 2004; Schmiedel 2005; Kumar, Maheswar and Reddy 2009)

| Biodiesel based on..../Diesel fuel | Density at 15.5 °C (g/cm³) | Viscosity at 40° C (mm²/sec) | Cetane number | Heating value (MJ/litre) | Diesel equivalent | Cloud Point °C |
|---|---|---|---|---|---|---|
| Palm oil | 0.88 | 5.70 | 62.00 | 33.26 | 0.92 | 13.00 |
| Soy oil | 0.88 | 4.08 | 46.20 | 35.18 | 0.98 | 2.00 |
| Castor oil | 0.93 | 13.75 | >51 | 36.66 | 1.02 | -23.00 |
| Sunflower oil | 0.88 | 4.60 | 49.00 | 33.53 | 0.93 | 1.00 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Animal fat | 0.88 | 4.10 | 58.00 | 34.99 | 0.97 | 12.00 |
| Rapeseed oil | 0.88 | 4.40 | 49.60 | 32.65 | 0.90 | -1.00 |
| Cotton oil | 0.85 | 6.10 | 53.00 | 34.44 | 0.95 | -2.00 |
| Diesel fuel | 0.85 | 2.0-4.5 | 51.00 | 36.08 | 1.00 | -1.80 |

# 1. Introduction

## 1.1. Objectives for the promotion of the production and use of biofuels

Biofuel production has grown considerably between 2004 and 2009. Global ethanol production more than doubled from 30 to 76 billion litres (1,609 PJ[1]) while global biodiesel grew eight-fold from 2 to 17 billion litres (550 PJ[2]) (REN21 Secretariat 2010, 13). In 2008, biofuels provided 2,109 PJ of fuel consumption, while global oil and natural gas consumption for the transport sector amounted to 93,282 PJ (International Energy Agency 2010). Mandatory blending of biofuels has been enacted in at least 41 states/provinces and 24 countries at the national level in 2009, and the EU Directive 2009/28/EC mandates the member states to ensure that at least 10% of the final consumption of energy in transport shall come from renewable sources (European Parliament 2009). Although specific framework conditions and objectives of these programmes differ from country to country, the following overall driving forces can be identified since they represent global challenges (International Transport Forum of the Organisation for Economic Co-operation and Development 2008a, 4).

In the international discussion, three main objectives are often cited to defend support policies for biofuels. This does not mean that there are not any other objectives nor that biofuels necessarily contribute to these objectives in a sustainable manner. The first important argument for promoting biofuel production and use is to reduce $CO_2$ and other greenhouse gases emissions from combustion of fossil energy in order to **mitigate climate change.** The anthropogenic greenhouse effect has received intense scientific and public attention in the last years. The Stern Review highlighted “the risks of serious, irreversible impacts from climate change associated with business-as-usual paths for emission” (Stern 2006). The fourth assessment reports of the Intergovernmental Panel on Climate Change (IPCC) stated “very high confidence that the globally averaged net effect of human activities since 1750 has been one of warming, with a radiative forcing of +1.6 W/m²” (Intergovernmental Panel on Climate Change 2007a, 3). Annual carbon dioxide concentration growth-rate between 1995 and 2005 (1.9 ppm/year) was higher than long-term average (1960-2005: 1.4 ppm/year) illustrating the need for further action beyond Kyoto Protocol targets. This applies especially for the transport sector whose carbon dioxide emissions grew by an over proportionally 37% between 1990 (4.6 billion tons of $CO_2$) and 2005 (6.3 billion tons of $CO_2$) compared to overall $CO_2$ emissions from fuel combustion (29% from 21 to 27 billion tons of $CO_2$) (International Transport Forum of the Organisation for Economic Co-operation and Development 2008b). In this context “biofuels might play an important role in addressing GHG emissions in the transport sector, depending on their production pathway” (Intergovernmental Panel on Climate Change 2007b, 18). Another important objective of biofuel production is to reduce dependency on expensive oil imports from few oil-exporting countries and increase energy security (Bush 2007). **Increasing international crude oil prices** pose a risk for net crude oil importing countries and are an indicator of growing concern about oil supply in the mid-term future. Although oil crude prices fell from a peak of more than 130 USD/bbl in July 2008 below 40 USD/bbl in January 2009, spot prices for crude oil quickly returned to the level before the outbreak of the economic crisis and surpassed 100 USD/bbl again at the beginning of 2011 (United States Energy Information Administration 2011). Biofuel production is also promoted in order to **stabilise prices for agricultural products and promote rural development** through cre-

[1] Lower heating value of fuel ethanol: 21.17 MJ/litre (26.8 MJ/kg) (Schmitz, Henke and Klepper 2009, 86)
[2] Lower heating value of biodiesel (palm oil methylester and soy oil methylester): 32.36 MJ/litre (37.2 MJ/kg) (Schmitz, Henke and Klepper 2009, 86)

ating an additional market beneath the food and feed markets. This applies to ethanol production from corn in the US, to biodiesel production from rapeseed in the EU, but also to the Brazilian alcohol programme which was created in a period of low international sugar prices. But the use of foodstuff for energy production also led to an international "food vs. fuel" debate (Doornbosch and Steenblik 2007; Food and Agriculture Organization 2008).

## 1.2. Studies on biofuel support policies and sustainability

At the beginning of the 2000s, several studies highlighting potential positive impacts of biofuel production and calculating the production potential of biofuels or bioenergy in specific countries and regions were published (Kojima and Johnson 2005; International Energy Agency 2004; Smeets, Faaij and Lewandowski 2005; Quirin et al. 2004). These studies focused on the technology pathways, the potential to mitigate greenhouse gas emissions, the estimated production costs, the land and feedstock availability and the impacts on rural income. The objective of these studies was to assess for political and economic decision-makers how to identify the biofuels production potential and the physical-technological conditions under which this potential could be exploited most efficiently. The biofuel policies of countries already producing considerable amounts of biofuel and the most important policy promotion instruments were portrayed, but not analysed profoundly in these studies.

But the growing concern among experts over negative impacts of an accelerated expansion of biofuels production lead to several studies about the sustainability of biofuel production. The report of the Worldwatch Institute[3] (Worldwatch Institute 2006) introduced a very comprehensive analysis of the global biofuel production and its impacts with several case studies (Brazil, China, Germany, India, and Tanzania). In the same year, a report by the University of Utrecht, Netherlands and the University of Campinas, Brazil, was published assessing the sustainability of the Brazilian ethanol production (Smeets et al. 2006). The sharp rise of food commodity prices (60% between April 2006 and April 2008, see (Trostle 2008) and reports about land clearing in sensitive ecosystems for cultivation of biofuel feedstock made the Round Table on Sustainable Development of the OECD criticise the biofuel support policies in OECD countries. An alternative policy agenda to address the challenge of energy security and GHG mitigation in the transport sector was recommended by the authors (Doornbosch and Steenblik 2007; Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen 2009).

There is still little empirical evidence to which extent global biofuel production based on foodstuff contributes to the price development of food commodities, to land clearing for biofuel feedstock cultivation and to other non-intended developments. But since it is also difficult to exclude these impacts, public support for biofuels now strongly depends on the economic, environmental and social performance of biofuels. This is why the European Union introduced a minimum sustainability criterion that biofuels have to meet in order to be eligible for quota requirements (European Parliament 2009). Thus, several studies have been realised with a focus on the performance and the impact of biofuel support policies on issues such as land use changes, Life Cycle Assessment (LCA) of biofuels, GHG mitigation costs, etc. (International Transport Forum of the Organisation for Economic Co-operation and Development 2008c). The goal of these studies is to identify the most promising and cost-effective tools to support biofuel production and consumption while minimising negative impacts along the whole value chain (United Nations Environment Programme 2009). Since the studies are directed to political and economic decision-makers, these assessments are very general and pragmatic and do not claim to explain why

[3] The study was prepared by the Worldwatch Institute for the German Federal Ministry of Food, Agriculture and Consumer Protection (BMELV), in cooperation with the German Technical Cooperation (GTZ) and the Agency of Renewable Resources (FNR).

certain biofuel support policies have been implemented and have led to a specific outcome in specific countries (UN-Energy 2007).

But from the perspective of political science and/or comparative policy analysis, this is an interesting question that shall be answered within this study. And in the next subchapter it will be explained why the Brazilian biofuel policy and production is an interesting case study.

## 1.3. Brazilian biofuel production as a case study in the scientific literature

Brazil already introduced a biofuel support policy (Alcohol Programme) in 1974/75 and has ever since produced considerable amounts of ethanol. Thus, Brazil is the only country with long-term experience in producing and utilising biofuels, and that is why it was and continues to be subject for several studies.

Four types of studies about the Brazilian biofuel production and policies can be differentiated:

1. studies about the ethanol production with a focus on technical and/or economic aspects highlighting the technical and economic feasibility of biofuel production with Brazil as an exemplary case;
2. studies about Brazilian ethanol policies and actors from a perspective of regime analysis and/or policy network analysis;
3. more recent studies analysing the overall performance of Brazilian biofuel (ethanol) production with regard to sustainability criteria, focusing on social and environmental aspects; and
4. studies about the Brazilian biodiesel programme introduced in 2004 with a focus on the social aspects of the biodiesel policies.

The **first type of study** has the objective to demonstrate the feasibility of biofuel production citing Brazil as an example and highlighting the lessons that have to be considered when trying to implement a similar programme in other countries. The study of José Roberto Moreira and José Goldemberg 1999 is typical for this type. Even during a stagnation of the programme they came to a quite positive evaluation of *PROÁLCOOL* and proposed to spread the use of ethanol internationally in order to increase Brazilian ethanol exports (Moreira and Goldemberg 1999). When interest in renewable energies in general and Brazilian ethanol experience specifically grew after the Johannesburg World Summit for Sustainable Development in 2004, several other studies were published focusing on the positive impacts of Brazilian ethanol programme (Goldemberg, Teixeira Coelho and Lucon 2004). A wide range of political, institutional and structural settings (focusing especially on research and development, logistics, infrastructure) and their impact on investment possibilities in biofuel production capacities were analysed in comprehensive studies in order to identify best practices for the promotion of biofuel production and consumption (Garten Rothkopf 2007; Garten Rothkopf 2009; Banco de Cooperação Internacional do Japão – JBIC 2006).

The **second type of study** about the Brazilian ethanol policy network is of great interest for this dissertation, since they analyse the decision-making process of biofuel policies. In 1987, De Castro Santos analysed the decision-making in the Brazilian sugarcane and ethanol sector with a focus on the fragmented and informal policy processes during the military regime between 1964 and 1986 (De Castro Santos 1987). Mello/Paulillo (2005) analysed the changes in the São Paulo sugar and alcohol policy network between 1975 and 2003 (De Mello and Paulillo 2005).

Although there are some studies that did already analyse sustainability of Brazilian ethanol in the 1980s and 1990s (Borges et al. 1984; Borges et al. 1988), most of the **studies of the third type** were realised within the last years due to the growing international concern over the sustainability of the biofuel production. Since Brazil is already exporting biofuels and still has a potential to increase these exports, the discussion about the sustainability is not only of academic but also of practical interest, considering that sustainability criteria already have or may be implemented in interesting import markets. A comprehensive study was realised in 2004 by Macedo with the main finding that the production and utilisation of anhydrous as well as hydrous ethanol helped to save more than 80% of green house gas emissions emitted by gasoline consumption (see Macedo, Lima Verde Leal and Ramos da Silva 2004; Macedo, Seabra and Silva 2008). Several studies assessing the overall economic, social and environmental performance of Brazilian biofuels production were realised in the past years (Goldemberg, Teixeira Coelho and Guardabassi 2008; Almeida, José Vitor Bomtempo and Carla Maria Souza e Silva 2007; Kaltner et al. 2005; Smeets et al. 2006; Giersdorf 2004). The analysis of the biofuel policies in these studies was restricted to a descriptive analysis of the amount of direct and indirect subsidies granted to the industry and the compliance of biofuel production with national social and environmental legislation.

The **fourth type of study** was motivated by the implementation of the Brazilian Biodiesel Programme in 2004. Since this programme puts special focus on social development through biofuel production by promoting feedstock production by small farmers in structurally weak regions like the semi-arid Northeast Brazil, and thus tries to integrate these vulnerable groups into the value chain, this production model provoked international interest as well. Thus, several studies are analysing these social aspects (Garcez and Vianna 2009; Laabs 2008; Mohr 2008) or are comparing the biodiesel programme with the ethanol programme with the aim to check the hypothesis that there are two different paradigms beyond the programmes (Nitsch and Giersdorf 2005; Giersdorf and Nitsch 2006; Hall et al. 2009).

## 1.4. Analysis of Brazilian biofuel policies from a perspective of political science

The main assumption for the present study is that the patterns of biofuel production and utilisation in Brazil are a result of a specific institutional framework and the actions of specific groups and that these factors also change over the years (Reydon and Ribeiro Guedes 2006). The existing studies about Brazilian biofuel production often neglect the analysis of the institutional framework and the main policy actors. Technological and economic aspects shall explain the success of the ethanol programme but the problem is that such an approach evokes that the main patterns of Brazilian biofuel production are predetermined by the physical-geographical conditions (soils, climate), the feedstocks and technologies used for production and the socio-economic conditions. This may lead to misleading conclusions, when trying to draw lessons for countries with a physical-geographical and socio-economic framework similar to Brazil. To avoid this type of misleading generalisation, this dissertation intends to describe and analyse the current ethanol and biodiesel policies in Brazil; to explain these public policies as a result of the interactions and resources of various actors involved into the formulation and implementation of these policies and to analyse selected economic impacts of these policies.

The decision-making process will be analysed with the methodological toolbox of the advocacy coalition approach by Sabatier (1993). This approach is appropriate for analysing the Brazilian biofuel policies since it enables to analyse the structure as well as the actors and the coalitions that dominate in this policy field. It will be presented briefly in chapter 2.1.2. The data on which this analysis will be based comprises primary sources like laws, regulations, official programmes and statements as well as secondary sources like scientific studies about Brazilian decision-making, political system and certain actors. In addition to that, several qualitative (semi-structured) interviews were conducted during field research in Brazil between January and September 2007. The design of the outline for the interviews as well as the realisation and interpretation of the expert interviews followed the methodological recommendations of Bogner, Littig and Menz (2005) and Laudel and Gläser  (2004). The methodology will be explained briefly in chapter 2.2. The main policies that shape Brazilian ethanol and biodiesel sector shall be analysed in chapter 3 and the production, distribution and consumption of biofuels in chapter 4. Based on these assessments, the analysis of the advocacy coalitions can be realised in chapter 5.

# 2. Theoretical and methodological framework

In the past years, interest in biofuel production and utilisation has grown dramatically due to several factors, most prominently increasing international prices for fossil fuels. Since Brazil is the only country with a 30-year experience in producing ethanol from sugarcane substituting 39 % of gasoline fuel demand for light vehicles in 2009, interest in Brazilian biofuel production has grown drastically. Depending on the point of view of the authors and the focus of the studies, the Brazilian case is seen as a successful example for sustainable low-cost ethanol production or as an example that large-scale biofuel production can cause negative social and environmental impacts. The evaluation of the sustainability of the Brazilian biofuels production and utilisation is very important when drawing lessons for other (tropical) countries that want to produce biofuels. Since the ethanol as well as the biodiesel production started with a governmental programme including blending targets and fiscal incentives, it is surprising that the current biofuel policies have not yet been analysed in-depth. For the ethanol programme, there are some brief studies (De Castro Santos 1987; de Mello and Paulillo 2005), but no comprehensive study. For the biodiesel policy there are many summarising descriptions of the main regulations of the biodiesel programme and recent studies on the social aspects of the biodiesel programme (Garcez and Vianna 2009; Hall et al. 2009), but no comprehensive analysis of these regulations and why they were formulated and implemented.

To fill this gap in scientific literature on Brazilian biofuel policies, the following questions shall be responded in the respective chapter of the present study:

- Chapter 3: What are the main policies regulating the production and the consumption of ethanol and biodiesel in Brazil?
- Chapter 4: What are the results of these policies regarding the biofuel production and consumption?
- Chapter 5: How can these policies be explained by the beliefs and the interactions of the most important actors aggregated in advocacy coalitions?

The main theoretical framework as well as the mix of the different methodologies for data collection and data interpretation will be described subsequently.

## 2.1. Theoretical framework

### 2.1.1. Policy analysis between scientific analysis and deliberative functions

Since the subjects of this study are the current Brazilian biofuel policies and its outcomes, it can be classified as a typical **policy analysis**. A short description of the objective of policy analysis is given by (Dye 1978): “Policy analysis is finding out what governments do, why they do it, and what difference it makes”. Thus, policy analysis is primarily defined through the explanandum, the dependent variable and not by a set of theories that are linked invariably to this kind of analysis. It aims at analysing every factor that influences actions of political actors and that manifests itself in regulations or programmes and their implementation (Schneider and Janning 2006). Policy analysts not only describe and explain policies scientifically but also give advice to political decision-makers in the formulation and implementation of policies (Schubert 2003, 37). With the functional differentiation of modern societies, the need to rely on highly specialised expertise increased strongly and since biofuel policies address complex issues which are surrounded by a high grade of uncertainty, they are a good example for this kind of policy analysis (see the study of the Interntaional Transport Forum of the Organisation for Economic Co-operation and Development (2008a) for instance for uncertainties about the effectiveness of biofuel production and consumption to mitigate GHG emissions).

The interpretation of policy analysis as an advisory tool dates back to the philosophical school of **pragmatism:** In a pluralistic world with a non-deterministic future for all individuals, intellectual thinking has to be put into practice and prove its utility (Schubert 2003, 39). This has important consequences for the concept of action within pragmatism since it does not differentiate between an ethical and an utilitaristic component: Action is seen as a reconstruction of experience, as a change and reorganisation of relationships between the actors and their environment. But the individual actor is also shaped by the influences and impacts of his or her social group (Schubert 2003, 39). This so called “social behaviourism” was developed by (Mead 1934) who urged for empirical observation to analyse the actions and interactions of individuals and groups. Thus, he introduced the empirical analysis of individual actors into political science which traditionally focused on political institutions and structures. But while the behavourialists focus on the political relevant behaviour of individuals and the impact of power and interest structures on political decisions, they neglect the special characteristics of political organisations. The neo-institutionalists argue that dominant societal interests are not reflected directly in the results of political decisions but are modified and filtered through the institutions of the political system (Keck 1991).

The **actor-centred institutionalism** developed by Mayntz and Scharpf (1995) is based on this neo-institutionalism and tries to overcome the dichotomy of actor-based (behaviourist) and structure-based (neo-institutionalist) approaches. According to these authors, institutions do not determine actions but institutional as well as non-institutional factors build a stimulating, enabling and restricting context for actions (Mayntz and Scharpf 1995, 43). The development and the results of a certain policy can be derived from the complex interactions of the relevant actors with the institutional framework that shapes but does not determine the actions of these actors (Schneider and Janning 2006). To which extent the actors use this framework to act depends on the basic orientations or belief systems of the actors and the specific situations. These basic orientations are shaped by a selection of interests and norms by the actors and result in stable preferences and internalised norms. Specific situations offer a stimulus and chances for actions which may be utilised by the actors depending also on their actual resources (Mayntz and Scharpf 1995, 43). Since the actor-centred institutionalism tries to integrate institutionalist and action-theoretical perspectives, it may be difficult and very complex to explain a certain action either by institutional or by one of the various non-institutional factors. The rule of the “decreasing abstraction” (Lindenberg 1991) helps to reduce the complexity, since in can be used in the sense that actor-based explanations do not need any institutional explanations and vice versa (Mayntz and Scharpf 1995, 43). The actor-centred institutionalism does not offer any content-related theory; it can be understood more as a heuristic concept to observe and analyse the actions and interactions of actors considering their institutional and non-institutional context (Mayntz and Scharpf 1995, 43). The question how and where to analyse these actions and interactions shall be answered subsequently.

Based on the system approach by *Easton 1971* – which describes the functional mechanisms (input, throughput, output and feedback) of the political system as a conversion process of problems, ideas and demands – the model of the **policy cycle** was developed (Easton 1971). In the model of the policy cycle, a legislative act undergoes a typical sequence of phases before its termination: the definition of the problem, the agenda-setting, the formulation of a policy, the implementation of a policy and the evaluation of a policy (Schneider and Janning 2006). By emphasising the analysis of the political process including the impact of a policy output, this concept represented an alternative to the traditional analysis of political institutions and their output and soon became very popular with political scientists and political decision-makers. But critics argue that the policy cycle model is not appropriate for analysing policies that consist of many different measures and that involve many interactions since it concentrates on one specific legislative action. The emphasis on the policy cycle as the temporal unit of analysis is problematic since there are always several parallel and interacting cycles on different political levels. Most important, the policy cycle concept does not offer any tools to explain policy-orientated learning during the political process (Sabatier 1993, 117). Based on this criticism, Sabatier and some other authors developed the approach of the advocacy coalitions as an alternative to the traditional policy cycle model. Since the study will use this framework for the empirical analysis of the Brazilian biofuel policy, the concept will be described briefly.

### 2.1.2. Advocacy Coalitions Framework as a concept for qualitative policy analysis

The **Advocacy Coalitions Framework** is based on three main assumptions:

1. The process of policy change and policy learning can be observed only in a period of at least one decade since a policy has to pass all phases of the cycle to be evaluated properly.
2. The analytical unit to observe this change is the policy-subsystem. This comprises the actors of public or private organisations that are involved actively into a policy problem.
3. Governmental measures can be interpreted as being based on or designed by basic orientations or "belief systems". These belief systems contain moral concepts, assumptions about important causalities, perceptions of states of the world and opinions about the effectiveness of specific policy instruments (Sabatier 1993, 117).

The **structure of the belief system** of an actor can be divided into three categories:

1. the "deep core beliefs" that contain normative and ontological axioms (assumptions about the nature of mankind, relative priority of values like freedom, security, welfare, knowledge e.g.) and that are valid for every subsystem;
2. the "policy core" that includes basic values and assumptions about causalities (general evaluation of the importance of a problem, distribution of functions between market and state, priority for certain policy instruments e.g.) and that depends on the subsystem; and
3. the "secondary aspects" that include a variety of instrumental decisions and processes of information-seeking (importance of specific aspects of a problem, decisions concerning administrative interpretations, information about the success of specific programmes e.g.) that are specific for a subsystem.

The core beliefs and the policy core are very resistant to changes and policy learning, only secondary aspects are likely to be adapted (Sabatier 1993, 117). The common beliefs are responsible for the coherence of policies – different from rational-choice-theories that emphasise the importance of short-term self-interests and that result in "coalitions of convenience" (Schneider and Janning 2006, 97).

Within a policy subsystem, the actors can be aggregated in several **advocacy coalitions** according to their common normative and causal concepts and the degree of coordination of their actions. In most of the cases there are between two and four different coalitions. Not every actor in a policy subsystem is part of a coalition or shares one of the "belief systems". It would be too complex to analyse any actor and single actors do not represent any strong coalition. Especially some scientists participate on the public debate because of their specific competence or knowledge but if they do not represent any institutional actor they are neglected here following the recommendations of the actor-centred institutionalism of Mayntz and Scharpf (1995). A specific function within the policy subsystems is played by policy-brokers that help reduce the intensity of a conflict in order to find a compromise between the conflicting strategies of the different coalitions (Sabatier 1993, 117). They shall be of course analysed if they can be identified.

Beyond the policy subsystem there are important **external variables** that influence the restrictions and the opportunities of the actors of the subsystem. When analysing policy change it is useful to differentiate stable parameters from dynamic factors:

1. Stable parameters include the main characteristics of a problem (public good e.g.), the basic distribution of natural resources (availability of oil, coal, etc.), the basic socio-cultural values and the social structure of a society and the basic characteristics of the constitutional structure (e.g. polity, presidential system).
2. Dynamic factors or external events include a change in the socio-economic conditions (e.g. prices for fossil fuels, availability of biofuel technologies), a change in the public opinion (concern about climate change), and a change of the government at federal level and policy decisions and impacts from other subsystems. Changes in these non-cognitive factors external to the subsystem like the macro-economic conditions or the inauguration of a new government are often responsible for changes of the core aspects of a policy (Sabatier 1993, 117).

This so called **policy learning** involves enduring changes of values and behavioural intentions within a coalition or a subsystem that result from experiences. The learning may include (1) a better understanding of the status of own goals and variables, (2) the improvement of the comprehension of the logical and causal relations within the own belief system and (3) the identification of and reaction to challenges of the own belief system[4] (Sabatier 1993). Policy learning may occur within an advocacy coalition or within the entire subsystem.

The Advocacy Coalitions Framework has been used in different national contexts to analyse political processes in several policy areas, such as the Dutch and Bavarian waste policy (Eberg 1997), the San Francisco Bay/Delta water policy (Sabatier and Zafonte 1999) and the forest certification policy in Canada, Indonesia and Sweden (Elliott and Schlaepfer 2001). The authors based their analyses on a broad range of different methodologies such as qualitative expert interviews, qualitative content analysis of statements, documents, etc. but also quantitative content analysis (Schneider and Janning 2006, 97). Thus this theoretical framework does not include any specific methodology and leaves this choice to the scientist who has to consider the object, the time framework and the data availability for the study.

[4] Sabatier (1993) illustrates these aspects of policy learning using the example of the US Clean Air Policy in the 1970s. The "Clean Air Coalition" tried to measure the air quality in order to better understand an important variable of public health, a core belief of this coalition (1). It also searched for new methods to reduce emissions per distance and the distance travelled (2). Since economists criticized the efficiency of the command and control concept and proposed economic incentives, the "Clean Air Coalition" within the Environmental Protection Agency integrated these incentives into the law not renouncing on the traditional command and control regulations (3).

In the present study the main assumptions and analytical instruments of the concept of the actor-centred institutionalism and the Advocacy Coalitions Framework shall be used for an inductive analysis of the Brazilian biofuel policies. They shall help to explain patterns of Brazilian biofuel policies (dependent variable) as the result of the actions and interactions of the main actors which can be grouped in advocacy coalitions (independent variable). External stable and more dynamic factors will be considered whenever necessary to explain the actions, the resources and the restrictions of the advocacy coalitions. Since this approach has not been used to analyse biofuel production and policies until now, the study can be considered as a qualitative case study on Brazilian biofuel policies with an explorative character.

## 2.2. Methodological framework

Within this study, several different methods were used in order to compensate the problems of a specific method through the advantages of another method. Expert interviews were realised, these interviews as well as documents, programmes, statements, etc. were interpreted and field visits of ethanol and biodiesel plants completed the analysis. The method of expert interviews and the qualitative content analysis as well as the reasons for opting for these methods within this research shall be described briefly.

### 2.2.1. Expert interviews as a qualitative method for policy analysis

As in many other studies, the use of expert interviews as a method of data collection was a pragmatic decision: as “points of crystallisation” of practical insider knowledge, interviews with experts are less time consuming than other methods of data collection like an involved observation or a quantitative analysis and simplify further access to the research field. There are three central dimensions of expert knowledge: the technical knowledge characterised by the administrative operations and the specific routines; the process knowledge, related to insights and information about actions and interactions, organisational constellations of past or present events; and the interpretation knowledge that includes ideas, orientations, values, etc. (Bogner and Menz 2005a). Especially the last dimension explains why this method is very appropriate to collect data within the framework of this study: The interview with an expert can help detecting the core beliefs and policy cores that form the “belief system” of the actors. It is an important task of the researcher to differentiate the described dimensions during the data collection and the analysis with the objective to construct the expert knowledge and the belief system of a corporate actor. But the expert knowledge is not only interesting because of its exclusivity: the knowledge of an expert is of special interest because it is very efficacious due to the position of the expert (Bogner and Menz 2005a). This applies especially to interviews with experts representing the functional elite, as in the case of this study. Within this research, an expert is defined as owner of specific knowledge in the area of biofuels representing or interpreting one or more of the actors that are thought to play an important role in biofuel policy. This implies the practical challenge to identify and to interview the expert that possesses the necessary knowledge and the representativity and that is accessible for a one-to-two-hour interview. Thus, there exist no rules how to select the “right” expert, since it is not necessarily the formal head of an organisation that disposes over the most important or influential knowledge or resources. Since the distribution of knowledge and power within the research area is unknown at the beginning of the analysis, the selection of the interview partners has to be an iterative process (Bogner and Menz 2005a).

The theoretical deficits and practical problems of this method should not be underestimated. The notion "expert interview" is used in very different contexts, and expert interviews often do not comply with the requirements of "openness" and "non-interference" of the qualitative paradigm, since normally the interviewer uses an outline to structure the interview (Bogner and Menz 2005b). But the outline also obliges the researcher to prepare the interview, helps to guarantee the technical quality of the interview and is an important prerequisite for the openness of the interview (Laudel and Gläser 2004). The outline helps to think about the function of a question and the general structure and the sequence of the questions, but still the approximation of the interview to a normal conversation including the specification of questions and the formulation of requests is more important than the standardisation of the interviews (Laudel and Gläser 2004).

There are no fixed rules about how to best realise an expert interview. The ascriptions of the interviewee to the interviewer, the interactions between researcher and expert and other processes should be seen as constitutive for this specific situation that differs substantially from a daily situation or a controlled experiment. Several ascriptions can occur and may help to guarantee the success of the interviews but can also lead to unsatisfactory interviews if they cannot be controlled. The interviewer can be perceived as a co-expert, as a competence holder in a different type of knowledge culture, as a complete layman, as an authority with superior knowledge or as an evaluator, as a potential critic or as an accomplice (Bogner and Menz 2005a). All these ascriptions may influence the interviews in a positive or negative way and in the present study another factor plays an important role. The interviews were realised in Portuguese by the German author of this study. The role as a "foreigner" may have reinforced the perception of the interviewer as a layman and/or a potential (foreign) critic and this had to be reflected during the interpretation of the answers. The interviews being realised in Portuguese was not considered a "technical" or language problem neither by the interviewee nor the interviewer, but of course the language and cultural differences may have lead to interpretations that differ from conclusions that a typical Brazilian researcher would have drawn.

### 2.2.2. Design and application of the expert interview outline

For this study, the selection of the experts was based on assumptions on the importance of the institutions represented by the interviewee, the professional competence and the position of the interviewee within the institution and of course on practical aspects such as the location of the institution and the availability of the interviewee. The organisations were divided into six general categories. The political sector with executive and legislative actors (federal ministries, federal deputies, regulatory agencies), the biofuel sector with raw material and biofuel production (farmers, cooperatives, ethanol and biodiesel industry), technology, energy and logistic companies with a close link to the biofuel industry (equipment manufacturers, mineral oil companies, traders, automotive industry), business associations (representing the biofuel industry or other companies), farmer associations and syndicates and non-governmental civil society organisations and research institutions (universities, private research institutes). In total, 53 expert interviews were realised between 2006 and 2007 and later on transcribed and interpreted (see table 41 in the annex for a complete list of the realised interviews). The categorisation followed pragmatic assumptions about the functions of the different actors within the biofuel policy system (policy-making, biofuel production, biofuel distribution). It did not consider assumptions about the values, positions, norms of the actors and therefore should not be confused with the aggregation of the actors in different advocacy coalitions which in fact should result from the methodology described.

Table 7 – Overview on realised interviews between 2006 and 2007

| Categories | Number of interviews |
|---|---|
| Political sector (federal ministries, regulatory agencies) | 15 |
| Biofuel sector (incl. feedstock suppliers) | 4 |
| Technology, energy and logistic sector | 9 |
| Business associations (biofuel sector and others) | 4 |
| Workers Organisations, Civil Society (NGOs) | 6 |
| Research and development | 15 |
| Total | 53 |

Since within this study experts from very different organisations were interviewed, the basic outline was adapted for each category represented, as recommended in the literature (Laudel and Gläser 2004). The general structure of the outline remained almost the same with the following main aspects being questioned: personal information (formation, work experience), position in the organisation, function within the execution of the biofuel programmes or objectives in the area of biofuels, resources to achieve these goals (including technical questions in the case of the biofuel producers for instance), collaboration with other actors in the biofuels area, participation in biofuel legislation or specific legislative or deliberative forums, participation in (inter)national discussion about sustainability of biofuels (executive or legislative actors, business or farmer associations, NGOs, science), cooperation with international investors or export activities (only in the case of industry).

### 2.2.3. Documentation and interpretation of expert interviews for qualitative policy analysis

For the purpose of this study, the topic and not the sequence of the statements are important for the interpretation of the expert interviews, since the same institutional context of the experts guarantees the comparability of the interview texts. The audio-taped interviews were not transcribed in detail, since the interpretation and not the detailed technical knowledge of the experts is of major interest within this research. A chronological paraphrase of the interviews was sufficient for a thematic comparison between the different interviews (Meuser and Nagel 2005). In a next step, the paraphrased passages of an interview were summarised under general titles which describe the main content of the statements. Similar titles from different interviews were compared in order to extract typical actions, observations, values, and orientations of one or another group of actors. The passages selected were translated by the author of this thesis and are used as quotations; however, it should be considered that they are not literal quotations of the interviewees and should be interpreted only within the specific context of the quotation.

## 3. Biofuel policies in Brazil since 1975

In the present chapter, the main Brazilian biofuel policies since 1975 shall be described. The focus will be on the current policies in the ethanol and biodiesel sector that help to promote biofuel production and consumption and that are the results of the interactions of the main actors that will be analysed later on. The current Brazilian biofuel polices will be analysed by using the classification of typical biofuel support policies of the Organisation for Economic Co-operation and Development (OECD) (International Transport Forum of the Organisation for Economic Co-operation and Development 2008a). The support measures cover the whole biofuel well-to-wheel chain: the biomass production, the biomass conversion, the biofuel distribution and export and the biofuel consumption (see table 8).

Table 8 – Typical support measures along the biofuel well-to-wheel chain (Giersdorf, based on based on (International Transport Forum of the Organisation for Economic Co-operation and Development 2008a))

| Biofuel well-to-wheel chain | Objective | Measures |
|---|---|---|
| Biomass production | Reduction of production costs | Direct subsidy per output of biomass (i.e. area payment) |
| | | General input subsidy |
| Conversion of agricultural biomass | Reduction of infrastructure costs | Capital grants |
| | | Credit guarantees |
| | | Enhanced capital allowances |
| | Direct reduction of production costs | Direct subsidy per unit of output of biofuel for the upstream producer |
| | | Income tax credit granted to the downstream producer |
| | Guaranteed price for biofuel | Feed-in-tariff |
| | | Green bonus |
| | Minimum market participation | Quota obligation scheme |
| Distribution of biofuels | Reduction of distribution costs | Fuel excise tax credit for biofuel blenders |
| | | Income tax credit blender |
| | | Direct subsidy to the blender |
| | Minimum market participation | Quota obligation scheme |
| | | Distributing infrastructure quotas |
| Biofuel consumption | Reduction of biofuel prices | Fuel excise tax exemption |
| | | CO2 excise tax exemption |
| | | VAT exemption |
| | | Income tax credit on purchase of renewable infrastructure (i.e. FFV) |

| | Minimum market participation | Quota obligation scheme |
|---|---|---|
| Overall | Commercial development of new technologies | (R&D) support schemes |
| | Protection of domestic biofuel industry and export promotion | Tariffs on biofuel imports |
| | | Imports tariffs on commodities |
| | | Non-tariff import barriers (i.e. fuel quality standards) |

## 3.1. Ethanol policies

The two main reasons for implementing the alcohol programme (*PROÁLCOOL*) in 1975 in Brazil were the high international crude oil prices and low international sugar prices. The importance of imported oil as a cheap source of energy and the importance of the sugar sector for the Brazilian economy explain why the alcohol programme was designed. Before the profound analysis of the current ethanol policies, a brief description of the history of Brazilian political and economic system shall help to understand the overall regulatory framework for the ethanol sector.

### 3.1.1. The Brazilian development model and its dependency on oil imports

Since the beginning of the import substitution industrialisation in the 1930s, Brazilian governments were prioritising the development of a national industry for consumer goods, prefabricated goods and capital goods. The metropolitan area of São Paulo became the industrial centre of Brazil concentrating national and multinational industry activities and headquarters. Since the domestic market had to be connected to this production centre and since the railroad and shipping infrastructure were restricted to specific ports connections satisfying only the needs of traditional export activities, the construction of new inter-state highways was promoted by the government since the 1950s. The setup of a national automotive industry through the collaboration with multinational automobile corporations had two objectives: to promote the national industrialisation process and to integrate the national territory and the domestic market. The dynamic of this development culminated in two boom periods (1955-61 and 1967-73) of the Brazilian economy, but increased the dependency of oil imports which reached almost 80% in 1974. When international oil prices rose from 2.59 USD/bbl in January 1973 to 10.95 USD/bbl in January 1974, the share of petroleum and derivates on import values increased from 11% to 23% thus showing the vulnerability of this development model. The energetic model was reformulated and to overcome the energy crisis, domestic crude oil production should be enhanced and the use of ethanol as a fuel should be promoted through the *Programa Nacional do Álcool* (National Alcohol Programme).

### 3.1.2. The sugar industry before 1975: surplus production and export growth

In 1933 the *Instituto de Açúcar e Álcool* (Sugar and Alcohol Institute) had been founded in order to regulate sugar production via production quotas, price guarantees and by commercialising the sugar in the domestic and international market. Notwithstanding a considerable increase in domestic sugar consumption since the 1930s, the production volume of sugar constantly exceeded the demand for sugar in Brazil. This was due to very generous financing of sugar commercialisation and price guarantees above inflation rates for the sugar producers, providing even the less efficient producers with some revenues. To remove sugar from the market, the *Instituto de Açúcar e Álcool* (IAA) tried to expand ethanol production in the 1950s but failed and sugar exports even had to be subsidised by the institute because of the low productivity compared internationally. It was not until the outbreak of the Cuban revolution of 1959 that Brazil got access to the preferential US market. Sugar exports increased fundamentally and changed completely the Brazilian sugar policies (Szmrecsányi and Pestana Moreira 1991). Through subsidised long-term credits for producers, the IAA wanted to turn Brazil into the leading sugar producer and exporter. After a overproduction crisis at the end of the 1960s, this policy was adjusted and incentives focused on the most efficient and biggest agricultural and industrial production units, therefore leading to a modernisation and concentration process. Between 1961/62 and 1971/72, sugar export volume increased 106%, against an increase of production of 50% and domestic consumption of 38% (Szmrecsányi and Pestana Moreira 1991). In 1973 Brazil exported almost 3 million tons of sugar with total revenue of 600 million USD, providing the *IAA* with significant financial resources. But instead of saving these resources or granting market credits, the *IAA* continued to subsidise credits for the expansion of sugar production facilities. When sugar prices declined dramatically from 0.62 USD/lb in November 1974 to 0.15 USD/lb in May 1975, the Brazilian sugar industry faced a severe crisis, since sugar exports already represented 30% of the total sugar production (Szmrecsányi and Pestana Moreira 1991).

### 3.1.3. 1975-1979: Creation of *PROÁLCOOL* and introduction of mandatory blend of anhydrous ethanol

In April 1974 the *Cooperativa Central dos Produtores de Açúcar e Álcool do Estado de São Paulo* (Association of the Sugar Producers of the State of São Paulo) and some plant manufacturing enterprises had sent a study to the *Conselho Nacional de Petróleo* (National Petroleum Council) proposing the construction of autonomous distilleries and introducing a price parity for alcohol and sugar. This price parity (44 litres of anhydrous[5] ethanol equalled 60 kg of sugar) was set by the *IAA* in mid 1975. But only after the presentation of a study realised by the *Secretaria de Tecnologia Industrial* (Secretariat of Industrial Technology) of the *Ministério de Indústria e Comércio* (Ministry of Industry and Commerce) the *PROÁLCOOL* was decreed in November 1975 by the President (Senado Federal 1975). The formulation and implementation of the programme revealed strong interest conflicts inside the federal government and its different agencies and between the economic forces involved into the programme. After the military coup d'etat of 1964, political power was concentrated in the executive, with the legislative and the judiciary reduced to ceremonial significance in Brazil. In general, the participation of social and economic actors on political decisions was very restricted under this authoritarian regime, but very important economic actors could address their requests through informal channels to the specific state agencies. The competition between these state agencies was fierce and the institutional design of the alcohol programme reflected the main cleavage between the *Ministério de Indústria e Comércio* (*MIC*), representing the interests of the sugar producers aggregated in the IAA, and the *Ministério de Minas e Energia* (Ministry of Mining and Energy), representing the interests of the state oil company *Petróleo Brasileiro S.A.* (*Petrobras*) (De Castro Santos 1987). The *Comissão Nacional do Álcool* (National Commission for Alcohol), that assembled several ministries, approved as much projects as possible but the *Banco do Brasil* (*BB*) and the *Banco Central* (Central Bank) rejected many projects because of the operative and/or inflation risk (De Castro Santos 1987). But despite this opposition, a lot of subsidised cred-

[5] According to the Brazilian ethanol fuel standard, anhydrous ethanol has an ethanol content of min. 99.6% vol. and is usually blended with gasoline (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2005).

its were granted at the end of the 1970s, and ethanol production increased rapidly and outperformed the initial production goal for 1980 of 3 billion litres. The *Conselho Nacional de Petróleo* (*CNP*) was authorised to change the amount of anhydrous ethanol in the gasoline and increased this share from the former nationwide 5% blend up to 10-15% in the main sugarcane producing states in the following years. Since all these measures did not ask for completely new alcohol production facilities and since the distribution structure and the end use technology did not have to be adopted for the higher blends, the first phase of the alcohol programme represented an intensification of what had been done prior to 1975 but did not signify a structural change in ethanol production and use of ethanol as a fuel. This was still to come after the second oil crisis 1979/80.

Since there is a vast scientific literature on the Brazilian alcohol programme, there is no need to analyse the programme in detail within this study. However, in order to understand the recent policies and development trends in the ethanol sector, it is necessary to portray the genesis of the alcohol programme briefly. The structure of the subchapters follows the distinction of (Rosillo-Calle and Cortez 1998) with the creation of *PROÁLCOOL* between 1975 and 1979 and the introduction of the blending of anhydrous ethanol to gasoline (chapter 3.1.3), the consolidation of *PROÁLCOOL* with the introduction of hydrated ethanol as a neat fuel between 1979 and 1985 (chapter 3.1.4), the expansion and constraints of the programme between 1985 and 1989 (chapter 3.1.5), the deregulation of the ethanol sector between 1990 and 2002 (chapter 3.1.6) and the renaissance of ethanol as a neat fuel and the introduction of flexible-fuel vehicles since 2003 (chapter 3.1.7). In the last subchapter, the current ethanol policies will be described in detail.

### 3.1.4. 1979-1985: Consolidation of *PROÁLCOOL* and introduction of hydrated ethanol as a neat fuel

Until the second half of 1978, ethanol production increased strongly and storage and distribution capacities reached their limits. The sugar lobby, some manufacturing enterprises and some state agencies pressured for investments in the distribution system and a further extension of the programme, because otherwise the realised investments into the sugarcane and alcohol production would become needless (Borges et al. 1984). When the *Centro Técnico Aeroespacial* (*CTA* - Research Institute of the Air Force) presented an alcohol motor in 1978, the national association of the automotive manufacturers abandoned its reluctant position to the alcohol programme and signed a contract with the government in 1979 promising to build alcohol cars in the subsequent years (Borges et al. 1984). But the crucial factor that accelerated the implementation of the second phase of *PROÁLCOOL* was the second oil crisis 1979 with increasing expenditures for oil imports. Until 1985 the annual production of ethanol should rise to 10.7 billion litres, of which 6.1 billion litres of hydrated ethanol[6] for the alcohol cars, 3.1 billion litres for the 20% blend with gasoline and 1.5 billion litres for the chemical industry (Borges et al. 1984). The *Conselho de Desenvolvimento Econômico* (Council for Economic Development) decided to separate the formulation and the execution of the alcohol and created the *Conselho Nacional do Álcool* (National Alcohol Council) and the *Comissão Executiva Nacional do Álcool* (National Executive Commission for Alcohol) (De Castro Santos 1987). The *Comissão Executiva Nacional do Álcool* (*CENAL*) became the most important agency for the regulation of the alcohol production and collaborated with the IAA when approving the implementation of new production facilities that since then also included the construction of autonomous distilleries producing only alcohol. Since the *Conselho Nacional do Álcool* (*CNAL*) was presided by the minister and the *CENAL* by the general secretary of the *Ministério de*

[6] According to the Brazilian ethanol fuel standard, hydrated ethanol has an ethanol content of min. 95.1% vol. and is used as a neat fuel (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2005).

*Indústria e Comércio*, this ministry finally achieved the hegemony over the alcohol policy, while the *Ministério de Minas e Energia* (*MME*) lost influence on the alcohol policy and energy policies in general.

The decisions concerning the financing of *PROÁLCOOL* were centralised in the *Secretaria de Planejamento* (Planning Secretariat) that administrated the *Fundo de Mobilização Energética* (Energy Mobilisation Fund) (De Castro Santos 1987). When the World Bank granted a 250 million USD loan in 1981, it "certified" the economic viability of the alcohol programme, thus attracting also private loans (Borges et al. 1984). Between 1980 and 1984, *PROÁLCOOL* received 7.5 billion USD, of which 55.5% were from public resources and 44.5% from the private sector (Paixão 1996). Most of these resources were transferred to the big sugar and alcohol producers through highly subsidised loans granted by the national banks[7]. The sugarcane cultivation area rose from 2.6 to 3.9 million hectares and total ethanol production increased from 3.7 to 11.9 billion litres between 1980/81 and 1985/86 (Ministério da Agricultura, Pecuária e Abastecimento 2007a). Annual sales of alcohol passenger cars reached a peak in 1986 with 619,290 units, representing 92% of total sales of passenger cars in this year. In 1989, the Brazilian fleet of alcohol passenger cars amounted to 4 million vehicles due to several tax reductions and exemptions (Petrobras - Petróleo Brasileiro S.A. 2011).

The interest conflict between high remunerations for the alcohol producers and low prices for the end consumers of the ethanol was resolved by establishing cross subsidies from gasoline sales. Annually the government mandated a guarantee price which Petrobras had to pay to the alcohol producers when purchasing total national ethanol production. Since all prices for fuels were determined by the government, prices of hydrated ethanol were fixed at a level never surpassing 65% of the gasohol price in order to (over)compensate additional consumption of neat ethanol (Borges et al. 1984). The taxes included in the final price for hydrated ethanol were either very low or even zero during *PROÁLCOOL*, while tax burden for gasohol always remained above 100% (Borges et al. 1984). The distribution of the profits from the alcohol programme turned out to be quite unequal. The production volume of alcohol and sugar increased mainly in the Centre-South and the large sugar and alcohol groups grew much faster than smaller producers (Paixão 1996). The segmentation of the federal bureaucracy into different agencies with restricted access favoured the enforcement of particular interests of the big capital and excluded certain groups like the sugarcane workers and small sugarcane growers (De Castro Santos 1987). In order to expand the production volume of alcohol quickly, the bureaucrats relied on the more efficient organisational structure of the huge sugar and alcohol groups where the enormous amount of resources could be applied (Borges et al. 1984). However, the development of the alcohol programme decelerated in the second half of the 1980s and came to an abrupt end in 1989, which will be analysed in the following subchapter.

### 3.1.5. 1985-1989: Expansion and constraints of *PROÁLCOOL*

In 1985, with the election of the president by the parliament, the democratisation process started and was completed formally by the adoption of a new democratic constitution in 1988 and the direct election of the president in 1989. The "phased withdrawal" of the Brazilian military was also caused by the obvious failure of the Brazilian development model based on deficit spending that had lead to a debt crises, hyperinflation, recession and growing poverty. The legitimisation of spending considerable public resources for the alcohol programme was questioned by the public that was concerned about the sub-

[7] In 1980, inflation in Brazil amounted to 110-120% p.a., while interest rates for *PROÁLCOOL* loans did not exceed 25% p.a. by a resolution of the *Conselho Monetário Nacional* (National Monetary Council). Between 1980 and 1982, the subsidy share of these loans surpassed 60% (Borges et al. 1984).

sidies, the accumulation of debt by the sugar and alcohol plants, the tax evasions, the social problems of the sugarcane workers and the general dictatorial way in which the programme had been implemented years before (Camargo Barros and Dias de Moraes 2002). The government limited new financial commitments and started to apply market conditions to the loans granted to the sugar and alcohol sector. International sugar prices rose gradually up to 0.15 USD/lb in 1989 and international crude oil prices declined from more than 30 to 20 USD/bbl in 1989. Many sugar and ethanol producers decided to increase the production of sugar for export and ethanol production stagnated at about 11 billion litres annually (Paixão 1996). But since the Brazilian alcohol car fleet demanded a constant and growing supply of hydrated ethanol, it came to shortages in ethanol supply. Paradoxically, Brazil even had to import ethanol and added 5% of gasoline to the hydrated ethanol to overcome the crisis of 1989 (Paixão 1996). The holders of ethanol cars lost their confidence in the alcohol supply and the alcohol programme, sales of alcohol cars declined and the production volume of ethanol shifted from hydrated to anhydrous ethanol (see figure 2 and table 42 in the annex).

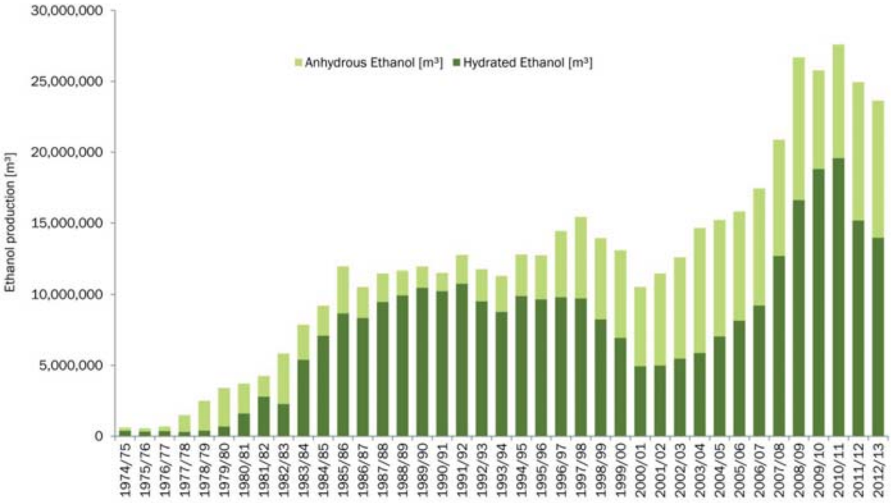


Figure 2 – Hydrated and anhydrous ethanol production in Brazil 1974/75-2012/13 (Giersdorf, based on(Ministry of Agriculture, Livestock and Food Supply 2009; Companhia Nacional de Abastecimento 2012))

## 3.1.6. 1990-2002: Deregulation of the ethanol sector

In 1988, the *Instituto de Açúcar e Álcool* lost its monopoly over sugar exports and the sugar producers could realise directly the export profits in this period of high international sugar prices. The dissolution of the *IAA* was part of a broader administrative reform that dissolved various other secretariats and agencies that had shaped the sugar and ethanol policies in the preceding years. In 1993, the *Comissão Interministerial do Álcool* (*CINAL* - Interdepartmental Commission for Alcohol) was established under the presidency of the *MME*, but this commission was transferred to the *Ministério da Indústria, do Comércio e do Turismo* (Ministry of Industry, Commerce and Tourism) in 1995. It was not until the creation of the *Conselho Interministerial do Açúcar e do Álcool* (*CIMA* - Interdepartmental Council for Sugar and Alcohol) in 1997 - that substituted the *Comissão Interministerial do Álcool* (*CINAL*) and still exists – that the sugar and alcohol policy formulation should get a new central decision arena (Camargo Barros and Dias de Moraes 2002). The *Conselho Interministerial do Açúcar e do Álcool* was first presided by the *Ministério da Indústria, do Comércio e do Turismo* (*MICT*) and assembled the *Ministério da Fazenda*, the *Ministério do Planejamento, Orçamento e Gestão*, the *Ministério da Agricultura, Pecuária e Abastecimento* and the *Ministério de Minas e Energia* beneath others. The Deliberative Committee of the Council assembled six representatives of the sugar and alcohol producers, four representatives of the sugarcane growers and one representative of the agricultural workers that could propose measures for the development of the sector (Presidência da República 1997b). Thus, since 1997 the different groups of the sector have a direct access to the council and the decisions of the council were considered when deregulating the sugarcane, sugar and alcohol sector and liberalising the sugar, sugarcane and ethanol prices in the 1990s (Camargo Barros and Dias de Moraes 2002). The price liberalisation represented the final point of a paradigm shift from a strong state control of the sugar and alcohol sector to limited regulation activities, thus leaving space for a self-regulation by the sector[8]. New associations of the sector were created in order to manage the transition process and to improve the representation of the sugar and alcohol producers in the political decision process. The *União da Indústria de Cana-de-Açúcar* (*UNICA* - Union of the Sugarcane Industry) substituted the *Associação das Indústrias de Açúcar e Álcool do Estado de São Paulo* (*AIAA* – Association of the Sugar and Alcohol Industries of the State of São Paulo) and other asociations of the sector and should become an important lobby group of the sugar and alcohol producers.

It should be mentioned that the liberalisation process was not limited to the sugar and alcohol sector in Brazil. The petroleum and fuels sector – dominated by the monopoly of the state oil company *Petrobras* since its creation in 1953 – was also deregulated in the 1990s. The Law 9.478 from 6/8/1997 (*Lei de Petróleo*) established the *Conselho Nacional de Política Energética* (*CNPE* - National Council for the Energy Policy) for the policy formulation and the *Agência Nacional do Petróleo, Gás Natural e Biocombustíveis* (*ANP* - National Agency for Petroleum, Natural Gas and Biofuels) for implementing these policies (Queiroz Pinto Jr. 2002). Ever since, other enterprises and not only Petrobras can explore, produce, refine and import or export crude oil, derivates and natural gas, too and the prices for fuels at the filling stations are completely liberalised since 2002. This means that since 2002 there is a free price competition between the hydrated ethanol and the gasoline-ethanol-blend at the filling stations, although federal and state governments can influence this relation considerably through taxation policies. Thus, the deregulation of the fuel sector was only completed in 2002. Since FFV were introduced into the market in 2003 and thus demand and production of hydrated ethanol grew again in 2003, this date shall be considered the starting point of the current ethanol policies shaping the sector, that will be analysed in the following subchapter.

### 3.1.7. Since 2003: Introduction of flexible-fuel vehicles and the renaissance of hydrated ethanol as a neat fuel

In this chapter, the current Brazilian ethanol polices shall be analysed by using the classification of typical biofuel support policies of the *Organisation for Economic Co-operation and Development (OECD)*

[8] One of the example of the self-regulation established by the sugar and ethanol producers represented by *UNICA* and the sugarcane growers represented by *ORPLANA (Organização dos Plantadores de Cana da Região Centro-Sul do Brasil* – Organisation of the Sugarcane Growers of the Centre-South region of Brazil*)* is the remuneration system for sugarcane acquired by the sugar and ethanol mills in the São Paulo state.

(International Transport Forum of the Organisation for Economic Co-operation and Development 2008c).

#### 3.1.7.1. Subsidised loans and financing lines for ethanol production

Since the creation of *PROÁLCOOL*, subsidised loans for the construction of sugar and ethanol mills served to promote ethanol supply. Even though the amount of subsidised loans decreased in the past decade, this form of governmental support remains very important. Several development banks at the federal, regional and state level are involved in financing ethanol activities with an outstanding position of the *Banco Nacional de Desenvolvimento Econômico e Social* (BNDES - National Bank for Economic and Social Development). Most of the funding programmes and financing lines for the agricultural sector – the implementation of modernisation projects (*FINEM*), the acquisition of domestically manufactured machinery (*FINAME*) and the support of the development of irrigated agriculture (*MODERINFRA*) - can be used for financing activities related to sugarcane, sugar and ethanol production. There are also financing lines for electricity co-generation projects, for the entry of small and medium enterprises into ethanol production (Leasing *FINAME*) and for supporting export activities (Garten Rothkopf 2007). Usually, the conditions of these loans include low remunerations for the bank and the long term interest rate *Taxa de Juros de Longo Prazo* (*TLJP*) that is set by the *Conselho Monetário Nacional*[9] (*CMN*) considering the development of the inflation rate. Since the base rate *Taxa SELIC (Sistema Especial de Liquidação e de Custódia)*, varied between 11% and 13% between 2007 and 2009[10] and interest rates of commercial banks were considerably higher than this, the long term interest rate of 6% to 6.5% represents an attractive condition for the sugar and ethanol industry (Banco Central do Brasil 2010). The *BNDES* is also responsible for the *Programa de Financiamento para estocagem de álcool combustível com garantia em produto*, a programme for the financing of the storage of up to 5 billion litres of ethanol which was introduced by the *CMN* in April 2009 as part of a package of support measures for the agriculture during the financial crisis (Banco Central do Brasil 2009). Even with various possibilities for funding of investments (external funds, regional funds, and equity capital), the loans of *BNDES* remain the most important source for funding, also in the perspective of the sector[11] (Antonio de Pádua Rodrigues 2007). The volume of new granted loans to the sugarcane, sugar and ethanol sector increased considerably in the last years, from 604 million BRL (2004) to 1 billion BRL (2005), 1.9 billion BRL (2006), 3.7 billion BRL (2007) and 6.5 billion BRL (2008) (Ministério do Desenvolvimento, Indústria e Comércio Exterior 2010a)[12].

In 2009, portfolio for the sector summed up to 25.5 billion BRL (incl. investments and financing) and focused primarily on sugar and alcohol production and to lesser extent on co-generation, sugarcane cultivation, and research and development (Cunha da Costa 2009). Percentage share of the sector on total granted *BNDES* loans increased from 1.2% (2004) up to 5.1% (2007) and this growing importance of the sector for the bank's activities was reflected by the creation of a new department, the *Departamento de Biocombustíveis* (*DEBIO*) of the bank in 2007 (Mainardes 2008). Thus, the increasing loans

[9] The *Conselho Monetário Nacional* is the highest decision-making body of the national financing system. It is constituted by the President of the *Tesouro Nacional* (National Treasury), the *Ministério de Planejamento, Orçamento e Gestão* and the President of the *Banco Central*.

[10] Due to the financial crisis, the base interest rate amounted to only 8.65% in January 2010.

[11] „The BNDES is the largest sponsor in the sugar and ethanol sector today because of financing the new production units. There exist various sources for financing, the BNDES, the external funds, initial public offerings at the stock market, sales of the own production, regional funds. But the largest sponsor is the BNDES."

[12] Compare major ethanol and sugar projects listed in table 44 and table 45 in the annex. These projects include grant volume of 1.6 bn BRL (2007) respectively 3.6 bn BRL (2008/09), despite the financial crisis.

granted by *BNDES* or subsidiary banks for the ethanol and sugar producers can be considered as an important policy tool to promote ethanol production (Dornelles 2007).

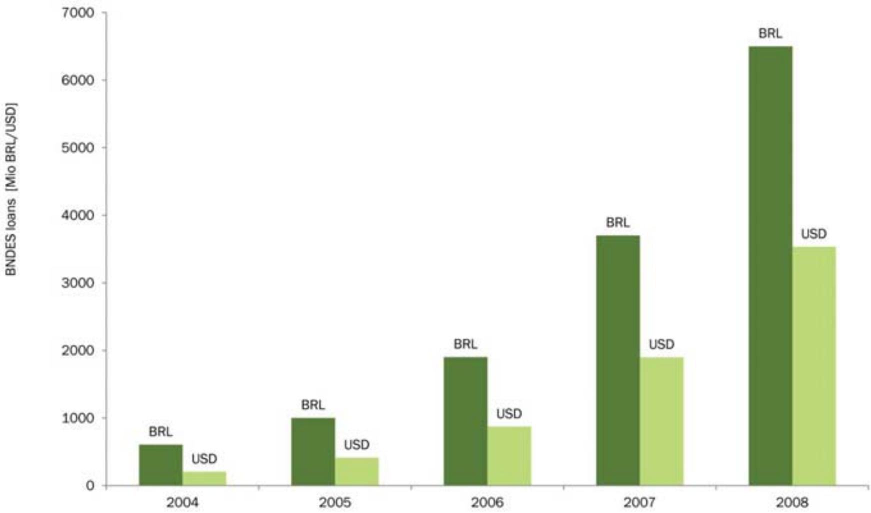


Figure 3 – Newly granted BNDES loans to the sugar and ethanol sector 2004-2008 (Giersdorf, based on (Ministério do Desenvolvimento, Indústria e Comércio Exterior 2010a))

### 3.1.7.2. Flexible blending target for anhydrous ethanol (20-25%)

The 20-25% share of anhydrous alcohol in the gasohol can be considered the most important policy tool to influence ethanol demand in Brazil. The growing demand for liquid transport fuels provides a minimum market for the ethanol producers. The *CIMA* establishes the ethanol share of Brazilian gasohol and the *Ministério da Agricultura, Pecuária e Abastecimento* (*MAPA* – Ministry of Agriculture, Livestock and Food Supply) executes the resolutions of this council. Since July 2007, ethanol share is fixed at 25% after it had been reduced to only 20% in 2006 after sharp price increase of ethanol (Ministério da Agricultura, Pecuária e Abastecimento 2010a).

By changing the share of *anhydrous* ethanol in the gasohol, the government indirectly influences the supply and the prices of *hydrated* ethanol since the ethanol producers can change the production volumes of anhydrous and hydrated ethanol. In March 2006 during a period of high prices for *hydrated* ethanol, the government reduced the share of *anhydrous* ethanol to 20% leading to an increase of supply of hydrated ethanol and a price decrease in the state of São Paulo – even before the start of the harvest of sugarcane in the Centre-South region in which prices tend to decrease due to increasing supply (see figure 4).

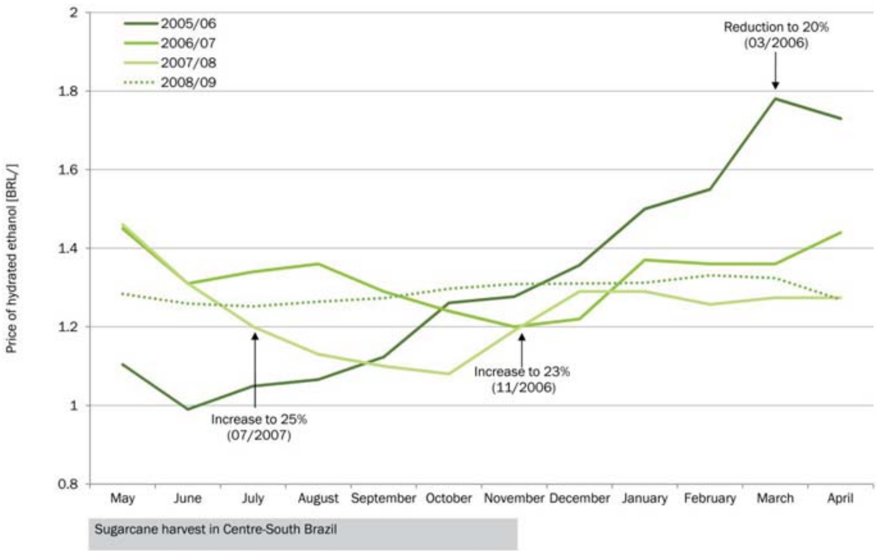


Figure 4 – Hydrated ethanol prices at petrol stations in São Paulo state and changes in mandatory share of anhydrous ethanol on gasohol, 05/2005-04/2009 [BRL/litre] (Giersdorf, based on (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2010a))

### 3.1.7.3. Tax reductions for ethanol fuel

Differentiated taxation of fuel consumption represents another tool to promote ethanol consumption and is used by the federal as well as state governments.

The *Contribuição de Intervenção no Domínio Econômico (CIDE Combustíveis)* is levied on the importation and commercialisation on fuels as an excise duty by the Brazilian federal government. The revenues from this contribution are assigned for subsidising fuels, financing environmental projects related to the petroleum and gas industry and financing infrastructure projects for the transport sector (Presidência da República 2001b). The rate for **hydrated** as well as **anhydrous ethanol** – and also for natural gas, heating oil and LPG - is **zero** (Presidência da República 2004a). For **pure gasoline**[13], this duty amounts to **230.00 BRL/m³** gasoline since June 2009 (Presidência da República 2009c). From 2004 to 2008, this excise duty amounted to 280.00 BRL/m³ gasoline, but had been reduced to 180.00 BRL/m³ in May 2008 in order to absorb impacts of the price increase of gasoline ex-refinery announced by Petrobras on April, 30th 2008 (Presidência da República 2008b). This duty is collected with the refineries and the importers of fuels.

There are two important social contributions, the *PIS (Programa de Integração Social e de Formação do Patrimônio do Servidor Público)* and the *COFINS (Contribuição para o Financiamento da Seguridade Social)*. Since they are levied not only on fuels but on all revenues originating from economic activities,

[13] Pure gasoline in Brazil is also called „Gasolina A“. Since gasoline is **always** blended with between 20-25% of anhydrous ethanol, depending on the effective regulation, pure gasoline is not available at fuel stations. The gasoline-ethanol blend is called „Gasolina C“ in Brazil.

they function more like consumption taxes in practice. For **hydrated ethanol**, there existed a cumulative tax regime with tax levy on the ethanol producers and the distribution companies until 2008, but in January 2008, President Luiz Inácio Lula da Silva answered the demand of the large distribution companies to concentrate the tax collection within the ethanol producers with the enactment of a *medida provisória* (provisory measure) (Presidência da República 2008a). In June 2008, this provisory measure was converted into Law 11,727 with some important changes claimed successfully by the ethanol lobby: Rates for the producers and importers were reduced and the distributors were now to be taxed as well. The specific rates for the producers and importers were reduced to 23.38 BRL/m³ (PIS) and 107.52 BRL/m³ (COFINS) while distributors have to pay 58.45 BRL/m³ (PIS) and 268.80 BRL/m³ (COFINS) (Presidência da República 2008c). Since collection is now non-cumulative, duties paid by the producers will be reimbursed by the distributors. The specific rates for ethanol fuel were reduced through a presidential decree and since October 2008 amount to 8.57 BRL/m³ (PIS) and 39.43 BRL/m³ (COFINS) for the producers and importers and to 21.43 BRL/m³ (PIS) and 98.57 BRL/m³ (COFINS) for the distributors (Presidência da República 2008d). Thus, for hydrated ethanol, tax burden for PIS/COFINS amounts to 120 BRL/m³ (0.12 BRL/litre), since it is a non-cumulative tax (compare table 9).

Table 9 – PIS/COFINS taxation of hydrated ethanol fuel (Giersdorf, based on (Presidência da República 2008a; Presidência da República 2008b; Presidência da República 2008c; Presidência da República 2008d; Presidência da República 2008e; Presidência da República 2009b; Presidência da República 2009c))

| | | Ad valorem rate (%) | Specific rate (BRL/m³) | Sum of PIS/COFINS for ad valorem rates (Non-cumulative) (BRL/m³) | Sum of specific rates PIS/COFINS (Non-cumulative) (BRL/m³) |
|---|---|---|---|---|---|
| PIS+COFINS (until 06/2008) | Producers | 3.65 | --- | 106.60 | --- |
| | Distributors | 8.20 | --- | | |
| PIS+COFINS (06-10/2008) | Producers | 8.40 | 130.90 | 273.00 | 327.25 |
| | Distributors | 21.00 | 327.25 | | |
| PIS+COFINS (since 10/2008) | Producers | 8.40 | 48.00 | 273.00 | 120.00 |
| | Distributors | 21.00 | 120.00 | | |

Most regulations for hydrated ethanol also apply to anhydrous ethanol. Until 2008, the ad valorem rates over the gross prices[14] for anhydrous ethanol used for the gasohol blend amounted to 0.65% (*PIS*) and 3.00% (*COFINS*) for the producers and importers and were zero for the distribution companies (Receita Federal 2005). The levy could be passed to the refineries and/or distributors which added the anhydrous ethanol to the gasoline. Thus, with prices ex-usina below 1000 BRL/m³ for anhydrous ethanol, *PIS/COFINS* amounted to 30 BRL/m³ anhydrous ethanol. Considering that 25% of Gasolina C[15] usually consists of anhydrous ethanol, its share amounted to about 8 BRL/m³. During 2008, *PIS/COFINS* taxation of anhydrous ethanol was changed just like taxation of hydrated ethanol. Since October 2008, the specific rates for the producers and importers amount to 8.57 BRL/m³ (*PIS*) and 39.43 BRL/m³ (*COFINS*) while rates for distributors are zero if anhydrous ethanol is sold as part of Gasolina C (Presidência

[14] Since there is no ICMS for anhydrous ethanol, gross prices do not differ from net prices.
[15] See footnote 13

da República 2008c; Presidência da República 2008d). Thus, tax burden for *PIS/COFINS* amounts to 48 BRL/m³ anhydrous ethanol and to 12 BRL/m³ for the share of anhydrous ethanol of *Gasolina C*.

For **gasoline**, taxation is concentrated at the refineries and the importers, but there exist also two forms of paying these taxes, a non-cumulative tax regime with ad valorem rates and a tax regime with specific rates. Ad valorem rates amount to 5.08% (*PIS*) and 23.44% (*COFINS*) while specific rates amount to 46.58 BRL/m³ (*PIS*) and 215.02 BRL/m³ gasoline (*COFINS*). Thus, with gross sale prices for *Gasolina C* about 2.40 BRL/litre in the past years, *PIS/COFINS* for the share of 75% of *Gasolina A* would amount to 563 BRL/m³ using the ad valorem system. Specific rates result in a much lower tax burden of 208 BRL/m³ for *Gasolina C* in order to promote the adoption of the less bureaucratic special regime by the refineries (see table 10) (Presidência da República 2004b; Receita Federal 2005).

Table 10 – PIS/COFINS taxation of anhydrous ethanol and gasoline (producers/importers) (Giersdorf, based on (Presidência da República 2004b; Presidência da República 2008c; Presidência da República 2008d; Receita Federal 2005)

| | Anhydrous ethanol | | Gasolina A | | Gasolina C[16] (2400 BRL/m³) | |
|---|---|---|---|---|---|---|
| | Ad valorem rate (%) | Specific rate (BRL/m³) | Ad valorem rate (%) | Specific rate (BRL/m³) | Weighted ad valorem rates (BRL/m³) | Weighted specific rates (BRL/m³) |
| PIS+COFINS (until 06/2008) | 3.65 | --- | 28.52 | 261.60 | 535.26 | 218.12 |
| PIS+COFINS (06-10/2008) | 8.9 | 130.90 | 28.52 | 261.60 | 563.76 | 228.93 |
| PIS+COFINS (since 10/2008) | 8.9 | 48.00 | 28.52 | 261.60 | 563.76 | 208.20 |

The most important tax in Brazil in terms of revenue is the value added tax ***Imposto sobre Circulação de Mercadorias e Serviços (ICMS)***, which is levied by the states and not the federal government. Thus, there exist different rates for the same product in different states and different rates for goods and services as a function of their origin or destination. In order to compete with other states for the settlement of enterprises, the state governments frequently change tax rates – a phenomenon which is called *Guerra fiscal* (fiscal war). Another peculiarity of the *ICMS* is that the constitution of 1988 determined that the *ICMS* has to be included into the added value of the good or service when calculating the *ICMS*. This means that the real value of the *ICMS* paid by the consumer is higher than the nominal value (Cavalcanti 2006). Thus, the tax is very complex and non-transparent but the constitutional embodiment creates high obstacles for essential changes. The *ICMS* for **Gasolina A** ranges between 20% in Amapá and 31% in Rio de Janeiro, but in most of the states the rate amounts to 25%. Since ICMS is calculated considering the gross sale price of the final product, *ICMS* rate for *Gasoline A* equals the rate for *Gasolina C*; there exists no rate for anhydrous ethanol. Considering the regional consumption of *Gasolina C* in the states, the medium *ICMS* amounted to about 26 % in 2008 (Own calculations based on(Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2010b; Ishihara 2006).

[16] 75:25 Gasoline:Ethanol

For **hydrated ethanol**, *ICMS* rates range between 12% in São Paulo and 30% in Pará, predominating 25% in most of the states (Biocomb 2007). Since 57% of total ethanol fuel is consumed in São Paulo, the weighted average *ICMS* rate amounted to 16% in 2008 (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2010b). Thus, there exists a tax advantage for hydrated ethanol of ten percentage points compared to *Gasolina C*. But since the reduction of *ICMS* rate for hydrated ethanol in São Paulo state from 25 % to 12 % in 2003 was also motivated by the objective to combat tax evasion[17] and to increase tax revenues for *ICMS*, the lower *ICMS* rate can not be considered exclusively a promotion policy for ethanol fuel (Assembleia Legislativa do Estado de São Paulo 2003). An overview of taxation of ethanol fuel and gasoline is given in table 11. The impact of the differentiated taxes on fuel prices and on tax revenues will be analysed in detail in chapter 4.2.6.

Table 11 – Overview of taxation of ethanol fuel and gasoline in Brazil May 2010

| | Hydrated ethanol[18] | Anhydrous ethanol | Gasoline A | Gasolina C (75:25; Gasoline:Ethanol) |
|---|---|---|---|---|
| CIDE | 0 BRL/m³ | 0 BRL/m³ | 230.00 BRL/m³ | 172.50 BRL/m³ |
| PIS+COFINS[19] | 120 BRL/m³ | 120 BRL/m³ | 261.60 BRL/m³ | 236.20 BRL/m³ |
| ICMS | 16% | - | 25% | 25% |

### 3.1.7.4. Tax reductions for alcohol cars and FFV

Another important tool to promote consumption of hydrated ethanol is a differentiated tax regime for gasoline, alcohol cars and flexible-fuel vehicles[20]. Sales of passenger cars are taxed with the *Imposto de Produtos Industrializados (IPI)*, a federal excise tax for industrialised products. Different tax burdens on gasoline and alcohol cars introduced during *PROÁLCOOL* remained valid during the 1990s, with the levy for alcohol cars always being five percentage points lower than for gasoline cars. Until 2001, IPI on passenger cars with an engine displacement of more than 1,000 ccm amounted to 20% for alcohol and 25% for gasoline cars. But this economic incentive is not very significant considering that *IPI* for passenger cars with an engine displacement of up to 1,000 ccm, the so called *carros populares* (popular cars) was and continues to be low independent of the fuel; it amounted to between 7% and 10% in the past years (Petrobras - Petróleo Brasileiro S.A. 2011)[21]. In 2002, a new taxation category for passenger cars with more than 1,000 ccm but less than 2,000 ccm was created. IPI for these cars amounted to 15% for gasoline and 13% for alcohol cars, thus reducing the tax advantage of the popular cars whose levy was reduced to 9%. But more important, by classifying the flexible-fuel vehicles as alcohol cars, the Brazilian government created the basis for the launch of the FFV in the Brazilian market in the subsequent year (Ministério do Desenvolvimento, Indústria e Comércio Exterior 2010a). Between 2004 and 2008 and again since April 2010, rates of *IPI* amount to 7% for popular cars, 11% (1,000-2,000 ccm)

[17] Distribution companies used to account fictitious inter-state sales in order to reduce the tax burden illegally, since ICMS rates for inter-state trade for hydrated ethanol are considerably lower (7 % and 12 %) than normal ICMS rates.
[18] PIS/COFINS for hydrated ethanol specific rate for distributors
[19] Only specific rates considered
[20] It should be considered that today, this incentive only indirectly stimulates ethanol consumption, since it stimulates sales of FFV which can either run on ethanol or gasoline.
[21] 1995, 1996 and 1998, IPI for cars up to 100 HP was 25% for gasoline and 20% for alcohol cars, for cars with more than 100 HP, this levy was 30% for gasoline and 25% for alcohol cars. IPI for cars with less than 1,000 ccm, levy was 8% no matter the fuel. In 1997, every levy was raised by five percentage points for one year. From 1999 until 2001, levy for cars up to 1,000 ccm was 10%, for cars with more than 1,000 ccm 25% for gasoline and 20% for alcohol cars.

and 18% (> 2,000 ccm) for FFV and 13% (1,000-2,000 ccm) and 25% (> 2,000 ccm) for gasoline cars (Presidência da República 2004c; Presidência da República 2006, see table 12).

Table 12 – IPI rates on passenger cars in Brazil 1999-2010 (Giersdorf, based on (Presidência da República 2004c; Presidência da República 2006c))

| | 1999 – 2002 | | 2002 - 2004 | | 2004–08, since 04/2010 | |
|---|---|---|---|---|---|---|
| | FFV/Alcohol | Gasoline | FFV/Alcohol | Gasoline | FFV/Alcohol | Gasoline |
| < 1 000 ccm | 10 % | 10 % | 9 % | 9 % | 7 % | 7 % |
| 1 000-2 000 ccm | 20 % | 25 % | 13 % | 15 % | 11 % | 13 % |
| > 2 000 ccm | 20 % | 25 % | 25 % | 25 % | 18 % | 25 % |

During the economic crisis 2008/09, the *IPI* rates on passenger cars were reduced in order to incentive car sales. Popular cars were even exempted from *IPI* between January and September 2009, while the difference between FFV and gasoline cars with 1,000 to 2,000 ccm was reduced to one percentage point. *IPI* rates on both FFV and gasoline cars increased stepwise between 2009 and 2010 and in April 2010, the rates returned to the level valid until 2008 (Presidência da República 2008e; Presidência da República 2009b; Martello 2009) (see table 13).

Table 13 – IPI rates on passenger cars in Brazil during the economic crisis 2008/09 (Giersdorf, based on (Presidência da República 2008e; Presidência da República 2009b; Martello 2009))

| | 01/01-01/09/2009 | | 01/09-31/10/2009 | | 01/11/2009-31/03/2010 | |
|---|---|---|---|---|---|---|
| | FFV/Alcohol | Gasoline | FFV/Alcohol | Gasoline | FFV/Alcohol | Gasoline |
| < 1 000 ccm | 0 % | 0 % | 1.5 % | 1.5 % | 3 % | 3-7 % |
| 1 000–2 000 ccm | 5.5 % | 6.5 % | 6.5 % | 8 % | 7.5 % | 9.5-13 % |
| > 2 000 ccm | 18 % | 25 % | 18 % | 25 % | 18 % | 25 % |

The differentiated *IPI* tax regime may represent a fiscal incentive to purchase FFV, but since the *carros populares* account for more than half of the passenger cars sold in Brazil, the flexibility to choose the fuel according to price relations or personal preferences independent from tax incentives explains the success of FFV in Brazil.

### 3.1.7.5. Funding of R&D on ethanol technologies

With the increasing global efforts to develop new technologies for ethanol production and Brazil's fear to loose its position as a technology and market leader, public funding for ethanol research and development activities increased in the past years (Soccol et al. 2010). Ethanol projects can be funded through the *Fundo Tecnológico (FUNTEC)* of the *BNDES* or the sectoral funds of the *MCT* which support renewable energy projects in general (see chapter 3.2.2.6). Between 2005 and 2007, *MCT* funded a study for the implementation of small-scale ethanol plants, the implementation of a laboratory for the certification of aero-engines running with ethanol (1.4 million BRL), the *Rede Interuniversitária para o Desenvolvimento Sucroalcooleiro* (*RIDESA* - Interuniversity Network for the Development of the Sugar and Ethanol Sector), and research and development in enzymatic hydrolysis of sugarcane (3 million BRL) (Ministério da Ciência e Tecnologia 2007a). Between 2008 and 2010, *MCT* planned to fund R&D projects with a total value of 168 million BRL through its sectoral funds (Ministério da Ciência e Tecnologia 2007b). A significant part of these resources was used to establish the *Centro de Ciência e Tecnologia do Bioetanol* (*CTBE* - National Centre for Ethanol Technology) in Campinas, SP (Laboratório Nacional de Ciência e Tecnologia do Bioetanol 2010).

Even though there is no exact data available, private funding is believed to exceed the public funding of R&D in the ethanol sector (Garten Rothkopf 2007). The *Centro de Tecnologia Canavieira* (*CTC* - Centre for Sugarcane Technology) in Piracicaba, SP is a private not-for-profit organisation and financed by the contributions of its members, the sugar and ethanol plants, cooperatives and sugarcane growers. It has an annual budget of roughly 30 million BRL and the most advanced research programme worldwide on sugarcane varieties with more than 60 different varieties. It is also developing genetically modified varieties and focuses on research and development of agronomy, agricultural and industrial engineering, and the production of sugar, ethanol and energy (Centro de Tecnologia Canavieira 2010). Since 1993, the capital goods manufacturer Dedini S/A Indústrias de Base, is developing a hydrolysis process for ethanol production from sugarcane bagasse and/or straw. This project was funded by Dedini itself (1.32 million BRL), Copersucar (0.5 million BRL) and the *Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP)*, the São Paulo research foundation (1.76 million BRL), and is one important example of a public-private partnership in ethanol R&D (Oliverio and Proenca Hilst 2004). Thus, there are various research and development projects being supported by the federal or state funding agencies in Brazilian ethanol sector. Very probably these activities will be intensified in the upcoming years and receive more private and public funding both from national and international companies since there is still a large need for research especially on new production technologies for ethanol from lignocellulosic feedstock such as bagasse and straw.

### 3.1.7.6. Tariff and non-tariff import barriers (e.g. fuel specifications)

The import tariff for un-denatured and denatured ethanol[22] used to be 20% until April 2010 when the import tariff was reduced to zero due to heavy rainfalls and lower harvest volume (Ministério do Desenvolvimento, Indústria e Comércio Exterior 2010b; Conselho de Ministros da Câmara de Comércio Exterior 2010). But since only the United States produce large quantities of ethanol fuel and most of this is used for the domestic market, the import barrier does not really represent an important support measure for Brazilian ethanol production. As already mentioned in chapter 3, fuel quality standards and specifications can be used as a non-tariff import barrier by a country. The specifications of fuel ethanol are regulated by *ANP* resolution N° 36 (2005).

The **appearance** of the ethanol must be clear and bright without any impurities and both types of ethanol have to be **colourless** before commercialisation (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2005). The obligation to add an orange dye to anhydrous ethanol was introduced in 2005 in order to detect adulterations; thus the orange colour is not a technical but a fiscal specification of the anhydrous ethanol. The specifications for **acidity, the ph value, chloride, sulphate, iron and copper** are

[22] 2207.10.00 -Álcool etílico não desnaturado, com um teor alcoólico em volume igual ou superior a 80% vol. and 2207.20.10 Álcool etílico of the *Nomenclatura Comum do MERCOSUL – NCM*.

all related to the corrosivity of the fuel and shall prevent long-term corrosion problems of engines running with ethanol or high ethanol blends. **Density** respectively **electrical conductivity** are only specified in Brazilian ethanol standard and not in Europe or the US and shall help to check water content or detect contaminants, which may increase corrosivity of the fuel. The minimum **ethanol content** for anhydrous ethanol is 99.6% vol. and 95.1% vol. for hydrated ethanol due to the different applications. The value for anhydrous alcohol is relatively high compared with US and EU specifications and is needed to provide proper calibration of the engines in Brazil (Tripartite task force Brazil, European Union & United States of America 2007). Even though the different ethanol fuel specifications may present non-tariff import barriers, they result from different historical developments and were not designed with the aim to impede imports. This is also obvious when analysing the specifications for *Gasolina C*, which is sold at the petrol stations. While ethanol share ranges between 20 and 25% in Brazil, ethanol content in EU is currently limited to 10% vol. for example. Thus analysis of Brazilian ethanol fuel specifications is important to understand Brazilian ethanol policies, but they can not be interpreted as an important support measure.

Table 14 – Anhydrous and hydrated ethanol fuel specifications in Brazil (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2005)

| Property | Unit | Anhydrous ethanol | Hydrated ethanol |
|---|---|---|---|
| Appearance | - | Clear and bright with no impurities | Clear and bright with no impurities |
| Colour | - | Colourless before adding orange colorant | Colourless |
| Acidity | mg/L | 30 | 30 |
| Electrical Conductivity, max. | µS/m | 500 | 500 |
| Density at 20°C | Kg/m³ | 791.5 max. | 807.6 – 811.0 |
| Total Alcohol content | °INPM | 99.3 min. | 92.6-93.8 |
| pHe | - | - | 6.0-8.0 |
| Gum residue by evaporation, max. | mg/100Ml | - | 5 |
| Hydrocarbons, max. | %vol. | 3.0 | 3.0 |
| Chloride, max. | mg/kg | - | 1 |
| Ethanol content, min. | %vol. | 99.6 | 95.1 |
| Sulphate, max. | mg/kg | - | 4 |
| Iron, max. | mg/kg | - | 5 |
| Sodium, max. | mg/kg | - | 2 |
| Copper, max. | mg/kg | 0.07 | - |

### 3.1.8. Conclusion

Brazilian ethanol support policies have changed considerably since the beginning of the alcohol programme (see table 15). During the authoritarian development model, competitiveness of ethanol was regulated directly by price control of the feedstock, the end products (sugar and ethanol) and the product to be substituted (gasoline). Ethanol production was subsidised heavily through national and international loans with very low interest rates and ethanol consumption was subsidised by price control and a very low tax burden for hydrated ethanol. After major political and economic changes, public support policies are limited at present, but a set of direct and indirect incentives continues. Investments in ethanol plants have been promoted recently via public credit lines with low interest rates, taxation of hydrated ethanol increased but continues to be lower than for gasoline, and consumption infrastructure still receives support although modern flexible-fuel vehicles do not run exclusively on ethanol fuel anymore. Thus, independent from the question of economic feasibility of ethanol production in Brazil, it is evident that public support policies still shape the ethanol fuel sector; although justification may partly have shifted from import substitution to GHG mitigation, since Brazil no longer imports large amounts of crude oil and derivates but is committed to climate change mitigation.

Table 15 – Public support policies for ethanol production and consumption in Brazil

| Biofuel well-to-wheel chain | Objectives | Measures | *PROÁLCOOL* 1975-1985 | Since 2002/03 |
|---|---|---|---|---|
| Conversion of agricultural biomass | Reduction of infrastructure costs | Capital grants and credit guarantees | 1980-1984: 4.16 billion USD subsidised public loans | 1.64 billion USD loans of BNDES with interest rates slightly above inflation rates |
| | | | 250 million USD world bank loan in 1981 | |
| | Guaranteed price for biofuel | "feed-in-tariff" | Price guarantees for sugarcane and sugar | - |
| | | | Price parity between Sugar and Ethanol | |
| | | | Ethanol prices set at 65% of gasoline | |
| Distribution of biofuels | Minimum market participation | Quota obligation scheme | 10-15% (1975) | 20-25% |
| | | | 20-22% (1984) | |
| Biofuel consumption | Reduction of biofuel prices | Fuel excise tax exemption | Tax burden for ethanol very low to zero | Federal excise duty:<br>Ethanol exempted;<br>0.14 BRL/l on Gasolina C |
| | | | Tax burden for gasohol about 100% | Social contributions:<br>0.12 BRL/l for ethanol;<br>0.22 BRL/l for Gasolina C |
| | | VAT exemption | - | Medium VAT rates:<br>16 % for ethanol |

| | | | | |
|---|---|---|---|---|
| | | | | 26 % for Gasolina C |
| | | Income tax credit on purchase of renewable infrastructure (i.e. FFV) | Reduction (exemption for taxis) of VAT for industrial products (IPI) | Reduction for alcohol cars and FFV (> 1,000 ccm) on VAT (IPI) |
| | | | Exemption from general VAT (ICMS) | Reduction for alcohol cars (not FFV) of motor vehicle tax (IPVA) in some states |
| | | | Reduction of motor vehicle tax (TRU) | - |
| Overall | Commercial development of biofuel technologies | R&D support schemes | n/a | Limited public funding |
| | Protection of domestic biofuel industry | Tariffs on biofuel imports | n/a | No import tariff on un-denatured and denatured ethanol[23] |

[23] 20% import tariff on un-denatured and denatured ethanol valid until April 2010

## 3.2. Biodiesel policies

### 3.2.1. Early initiatives for a biodiesel programme: PROÓLEO and OVEG

In 1937, the first patent for the transformation process of vegetable oil into biodiesel was registered in Belgium. During World War II, several studies on the energetic use of vegetables oils were realised but later on abandoned in Brazil and other countries (Suarez and Meneghetti 2007). The interest in biodiesel was renewed in Brazil with the rise of crude oil prices in the 1970s and in 1980, the *Programa Nacional de Produção de Óleos Vegetais para Fins Energéticos (PROÓLEO* - National Programme of Vegetable Oil Production for Energetic Use) was created. Until 1985 additional supply of vegetable oils for energetic use should grow to 1.6 million m³ annually. But the programme was not implemented and the large-scale substitution of diesel fuel through vegetable oil was never realised, since international quotations of vegetable oils were at least twice as high as for crude oil and with a diesel price of 40 USD/bbl, costs for biodiesel ranged between 67 USD/bbl (palm oil) and 148 USD/bbl (peanut) (Mattar 1982). Thus, while the large-scale utilisation of vegetable oils in the transport sector was not implemented, research and development activities were promoted within the scope of another programme, the *Programa Nacional de Energia de Óleos Vegetais (OVEG* - National Programme of Vegetable Oil Energy) that was launched in 1981 by the *Secretaria de Tecnologia e Indústria* of the *Ministério de Indústria e Comércio* (Secretary for Technology and Industry of the Ministry of Industry and Commerce). Isolated experiences of research institutions should be collected and made available nationwide and tests with vegetable oil as a fuel should be realised with normal diesel fleets. National and multinational manufacturers of compression ignition (diesel) engines, distribution companies, transport companies, governmental agencies and various research and development institutions participated in the tests that focused primarily on methyl and ethyl esters of soy oil. The results confirmed the technical viability of using esters or blends in diesel engines, but the programme was abandoned due to decreasing oil prices in the mid 1980s (M. M. de Azevedo and N.M. Pereira 2007). But some Brazilian researchers from the *Fundação Centro Tecnológico de Minas Gerais* (Technology Centre Foundation of Minas Gerais), the *Universidade Federal do Ceará* (Federal University of Ceará) and the *Universidade Estadual de Campinas* (State University of Campinas) continued their research on biodiesel and registered the first Brazilian patents on the transesterification process (Suarez and Meneghetti 2007). The *Universidade Federal do Paraná* (University of Paraná) developed a production process for soy oil ethyl esters and in 2000 the company ECOMAT constructed a plant in the state of Mato Grosso to produce a diesel additive from soy oil. And also public institutions like the MCT and the MDA funded some activities like the PROBIOAMAZON with the objective to produce palm oil in settlements of the *Instituto Nacional de Colonização e Reforma Agrária* (*INCRA* - National Institute for Colonisation and Agrarian Reform) (Ministério da Ciência e Tecnologia 2002b).

With the rise of the international oil prices in the 2000s, another effort was undertaken to connect the isolated research activities and to implement biodiesel blending with fossil diesel: The *Programa Brasileiro de Desenvolvimento Tecnológico de Biodiesel* (Brazilian Programme of Technological Development of Biodiesel) was created in 2002 during the presidency of Fernando Henrique Cardoso with the aim to promote the scientific and technological development of ethylic biodiesel (Ministério da Ciência e Tecnologia 2002a). A research and development network with several work groups (fuel specification, technological feasibility, social-ecological and economic feasibility, etc.) was founded and research institutions, Petrobras, the *Ministério da Agricultura, Pecuária e Abastecimento*, the *Associação Nacional dos Fabricantes de Veículos Automotores* (National Association of the Car Manufacturers), the *Associação Brasileira das Indústrias de Óleos Vegetais* (Brazilian Association of the Vegetable Oil Industry), the *Agência Nacional do Petróleo, Gás Natural e Biocombustíveis* (National Agency for Petroleum, Natural Gas and Biofuels) and others participated in the different work groups between 2002 and 2005. The creation of the network was justified with the large quantities of soy feedstock for biodiesel production and the considerable imports of diesel fuel that should be substituted. The results of the research activities and the implementation of a 5% vol. blend of biodiesel until 2005 should help save $CO_2$-emissions and turn Brazil into a "world leader in biofuels" (Ministério da Ciência e Tecnologia 2002a). Thus, this network can be considered the starting point for the formulation of a national biodiesel programme that will be presented in the following chapter.

### *3.2.2.* Implementation of the *Programa Nacional de Produção e Uso de Biodiesel*

After the assumption of office of president Luiz Inácio Lula da Silva in 2003, the new administration adopted the idea of introducing biodiesel into the national energy matrix and on 2nd of July 2003 an interdepartmental work group was created by a presidential decree. Within 90 days, the group should elaborate a report on the feasibility of the utilisation of biodiesel and send this report together with recommendations for necessary measures to the *Câmara de Políticas de Infra-Estrutura* (Chamber of Infra-Structure Policies), an advisory council of the government.

The working group was composed by representatives of the presidency (*Casa Civil*) and eleven ministries[24]. In several meetings the working group consulted federal deputies, federal agencies (*ANP*, *EMBRAPA*), associations of the agricultural and car manufacturer sector, various researchers and some enterprises that planned to produce or already were producing biodiesel in pilot or small plants. The four thematic subgroups on the production capacity, the technological aspects, and the use of biodiesel as a fuel, and the incentives and financing contributed to the final report that was concluded in December 2003. Among other things, this report recommended to create a permanent (steering) interdepartmental commission which should accompany the implementation of the public biodiesel policies that were to be defined by the government in the future[25] (Grupo de Trabalho Interministerial 2003). The executive interdepartmental commission proposed by the working group was created by presidential decree in December 2003 and included representatives of the ministries that had elaborated the final report as well as a representative of the *Ministério do Trabalho e Emprego* (Ministry of Labour) (Presidência da República 2003). For implementation of the decisions of the executive group, a steering group including representatives of ten ministries and of *BNDES*, *ANP*, Petrobras and *EMBRAPA* was created, and the discussions of this group resulted in some important legal measures in 2004.

[24] *Ministério do Transporte* (Ministry of Transport), *Ministério da Agricultura, Pecuária e Abastecimento* (Ministry of Agriculture, Livestock and Supply), the *Ministério do Desenvolvimento, Indústria e Comércio Exterior* (Ministry of Development, Industry and Commerce), the *Ministério de Minas e Energia* (Ministry of Mining and Energy), the *Ministério da Fazenda* (Ministry of Finance), the *Ministério do Planejamento, Orçamento e Gestão* (Ministry of Planning, Budget and Management), the *Ministério da Ciência e Tecnologia* (Ministry of Science and Technology), the *Ministério do Meio Ambiente, dos Recursos Hídricos e da Amazônia Legal* (Ministry of Environment, Water Resources and Legal Amazon), *Ministério do Desenvolvimento Agrário* (Ministry of Agrarian Development), the *Ministério da Integração Nacional* (Ministry of National Integration) and the *Ministério das Cidades* (Ministry of Cities).

[25] The working group also recommended: to incorporate the biodiesel immediately into the official agenda of the government with the intent to promote its production and use; to promote decentralized and non-exclusive production and use of biodiesel in order to promote the social inclusion and the regional development especially in the North and the Northeast; to authorize the use of B5 nationwide but not to mandate it, since this would exclude Brazil from possible benefits of carbon credits within the framework of the Clean Development Mechanism (CDM); to include small farmers into the production chains of the biodiesel through financing, technical assistance and organisation; to implement public policies (e.g. financing, research) with the intent to increase the agricultural and agro-industrial efficiency of the biodiesel production, thus excluding the necessity of subsidies; and to establish standards and regulations for the quality of the biodiesel and the emission control (Grupo de Trabalho Interministerial 2003).

With the provisory measure N° 214, President Lula da Silva introduced biodiesel fuel into the Brazilian energy matrix in September 2004 and empowered the regulatory agency *ANP* to issue further regulations concerning the new fuel (Presidência da República 2004d). In November 2004, *ANP* regulated the production of biodiesel, authorised the addition of up to 2% vol. of biodiesel to mineral diesel and specified the characteristics of the biodiesel, although for many parameters only a reporting duty was introduced but no threshold values fixed (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2004a; Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2004b). During an official ceremony for the launch of the *PNPB – Programa Nacional de Produção e Uso de Biodiesel* (Brazilian Biodiesel Programme) in Brasília on 6th of December 2004, president Lula signed the provisory measure N° 227 that regulated the fiscal registration of the biodiesel producers and importers and the incidence of the federal social contributions *PIS* and *COFINS* on biodiesel production and imports (Presidência da República 2004e). Art. 5 of this measure authorised the executive power to fix a reduction coefficient for the rates of the social contributions and the analogous presidential decree was issued the same day and established differentiated reduction coefficients for the social contributions *PIS/COFINS* (Presidência da República 2004f). Another decree issued on 6th of December set the rate of the IPI on 0%. A resolution of the national development bank *BNDES* created a programme for the financial support of investments within the framework of the national biodiesel programme (Presidência da República 2004g; Banco Nacional de Desenvolvimento Econômico e Social 2004). Thus, the most important regulations on the taxation and the financial support of the new renewable fuel were implemented on the day of the official launch of the programme. However, it should be considered that this launch occurred on the basis of two provisory measures that still had to be transformed into law by the Brazilian parliament[26]. This explains why in his speech during the official ceremony, President Lula did not only refer to the social and environmental aspects of the programme in general, but emphasised the enormous importance of this programme for the Brazilian Northeast and invoked the solidarity of the deputies from all regions when voting on the provisory measure (Luiz Inácio Lula da Silva 2004).

The implementation of the biodiesel programme is an example of the legislative power of the Brazilian president and the use of provisory measures as a tool for agenda-setting. A provisory measure on which the Brazilian congress does not vote within 45 days automatically is set on top of the congressional agenda, a phenomenon also known as *trancamento da pauta* ("jamming up of the bill flow") or lockdown of the agenda (Carlos Pereira, Power and Rennó 2006). The option for the use of the provisory measure was motivated by the will of the president "to take leadership in the institutionalisation of the *PNPB*"[27] and to prevent political bargaining processes that could last for years, since the presidency feared opposition from the agro-business in the Centre-South because of the fiscal incentives for biodiesel production in the Northeast (Rodrigo Rodrigues 2007).

A parliamentary bill proposing a minimum blend of 5% vol. ethyl esters to diesel from 2004 on had been already presented in the last year of the Cardoso administration by the federal deputy Antônio Carlos Mendes Thame (PSDB/São Paulo)[28]. But this bill was never voted and finally archived in 2005 when the

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[26] The provisory measure N° 214 had been voted by the *Câmara dos Deputados* but not by the *Senado* before the launch of the programme.

[27] "The decision for the provisory measure and not for a parliamentary bill was taken because the president wanted to be in the forefront of the implementation of the biodiesel programme. You issue a provisory measure when there is urgency and relevance, because of the incentives for the Northeast and the small farmers. This could provoke an opposition from the agro-business in the Centre-South, of the soy farmers, the agricultural lobby in the congress. And the time it would take in the Congress with this controversy was unpredictable, it could take two, three years, therefore it was set in motion as a provisory measure."

[28] This bill was presented by the federal deputy Antônio Carlos Mendes Thame of the PSDB from São Paulo and proposed a minimum blend of 5% vol. ethyl esters from 1st January 2004 and a minimum blend of 15% vol. ethyl esters and 5% vol. of anhydrous alcohol to diesel from 1st of January 2006 on (Zica 2004). The original proposal was influenced by the findings and

provisory measure N° 214 was transformed into Law N° 11.097 by the *Congresso Nacional*. But one important regulation proposed by the parliamentary bill and not the provisory measure became part of the law: a blend of 2% vol. biodiesel that should become mandatory within three years and an increase to 5% vol. that should become mandatory within eight years or earlier if decreed by a resolution of the *CNPE – Conselho Nacional de Política Energética* (National Council for Energy Policies) (Presidência da República 2005a). The provisory measure N° 227 (06/12/2004) with the regulations concerning the taxation of the biodiesel was transformed into law N° 11.116 (18/05/2005) with no significant changes by the congress. The coalition of deputies from the North and the Northeast and deputies favouring small farmers prevailed over the agricultural lobby from the Centre-West, the Southeast and the South. Art. 5 of Law 11.116 authorised the executive power to change the reduction coefficient for biodiesel taxation at any time (Presidência da República 2005b).

After this description of the genesis of the biodiesel programme, the specific policies promoting biodiesel production and consumption will be presented and analysed in detail in the following subchapters. The analysis will follow the methodology already described in the chapter on ethanol policies.

### 3.2.2.1. The *Selo Combustível Social* as a pre-requisite for support measures

One important regulation of the Brazilian biodiesel programme is the concession of the *Selo Combustível Social*, a social seal by the MDA. The biodiesel producers most comply with the following regulations in order to acquire the social seal:

- purchase of part of their raw material from family agriculture29 (50% in the Northeast and Semi-arid regions; 30% in the Southeast and South; 10% in the North and Centre-West, calculated on the purchase price);
- signing contracts with the family agriculture or their cooperatives which are approved by the representation of the family agriculture;
- commitment to provide technical assistance and training for family agriculture which will supply raw material (Ministério do Desenvolvimento Agrário 2005).

An accredited representation of the family farmers (*CONTAG*, *FETRAF*, *ANPA*, etc.) participates in the negotiations and the social seal is granted for five years, with an annual external examination and an

intentions of the PROBIOIDIESEL, but it was modified during consultations in various committees and several other parliamentary bills were attached to this proposal during 2003 and 2004.

[29] Since 1st of July 2008, there are three different groups of small farmers within PRONAF: 1) small farmers who have been resettled within the *Programa Nacional de Reforma Agrária* (*PNRA* – National Programme for Agrarian Reform), whose property does not exceed one *módulo fiscal* and whose annual income does not exceed 14,000 BRL; 2) small farmers which cultivate their own property or leased land, which reside on that land or nearby, with the area not exceeding four *módulos fiscais*, which obtain at least 30% of their income through agriculture, and whose annual income does not exceed 4,000 BRL; and 3) small farmers which cultivate their own property or leased land, which reside on that land or nearby, with the area not exceeding four *módulos fiscais*, which obtain at least 70% of their income through agriculture and whose annual income is between 4,000 BRL and 110,000 BRL (Banco Central do Brasil 2008). The *módulo fiscal* serves as a parameter to classify land property by its size. The size of the *módulo fiscal* is fixed by the *municípios* (counties) considering the type of exploration predominant in the county, the income obtained with the dominant exploration and the concept of family property. The medium size of the *módulo fiscal* ranges between 20 ha in the Southeast and 90 ha in the North (Instituto Nacional de Colonização e Reforma Agrária 2008). Once registered within the *Programa Nacional de Fortalecimento da Agricultura Familiar* (*PRONAF* - National Programme of Strenghtening of Family Agriculture), family farmers can receive subsidised credits to cover the cost of their agricultural activities or for investments. Interest rates of the loans range from 1% to 5.5% p.a. depending on the financing volume and the objective and in 2007/08 harvest, loans with a volume of 9 billion BRL were granted for 1.6 million contracts (Ministério do Desenvolvimento Agrário 2010a). In 2006, 4.37 million (84%) establishments of the 5.18 million agricultural establishments in Brazil were run by family farmers, occupying an area of 80 million ha, 24% of total area used for agriculture and cattle breeding in Brazil. The gross value of the production of the family farmers amounted to 41 billion BRL, representing 34% of total agricultural gross production of 122 billion BRL (Instituto Brasileiro de Geografia e Estatística 2006a). Thus, small farmers represent an important part of the Brazilian agriculture, although with different regional participation and this is also why minimum participation of feedstock supply by family farmers varies between the different regions.

evaluation by the MDA. The social seal may be suspended for one year if the biodiesel producer does not comply with the prerequisites. In May 2010, 30 biodiesel production units (of 23 different enterprises) were holding the social seal (Ministério do Desenvolvimento Agrário 2010b). The social seal is the pre-requisite to benefit from several support measures of the biodiesel programme such as:

- specific financing lines for biomass production and conversion (see chapter 3.2.2.2),
- privileged participation in biodiesel auctions (see chapter 3.2.2.4), and
- differentiated reduction of federal taxes (see chapter 3.2.2.5).

### 3.2.2.2. Financing of feedstock cultivation, oil extraction units and biodiesel plants

With the introduction of the biodiesel programme in December 2004, the national development bank *BNDES* issued a resolution that created a financial support programme for the production and use of biodiesel as an alternative source of energy (Banco Nacional de Desenvolvimento Econômico e Social 2004). This programme finances investments in every phase of the biodiesel production process including cultivation of feedstocks, extraction of raw vegetable oil as well as biodiesel production and storage facilities. Investments in the utilisation of co- or by-products of the biodiesel production will be supported as well as the acquisition of machinery authorised for the use of B20 or higher blends of diesel fuel with biodiesel or straight vegetable oil. The resolution did not create any new financing lines but used existing financing programmes and lines and introduced special regulations for investments related to biodiesel production or use. The acquisition of machinery authorised for B20 or higher is funded through the existing financing lines in this area (*FINAME, FINAME AGRÍCOLA, FINAME LEASING*) but extends the normal amortisation period for up to 25%. In accordance with the general *BNDES* policies, only loans with a volume of at least 10 million BRL are operated directly by the *BNDES* (called *Apoio direto*). Loans with less than 10 million BRL are operated by national or regional state or development banks (e.g. *Banco do Brasil, Banco do Nordeste, Banco da Amazônia, Caixa Econômica Federal)* or by any other private bank (*Apoio indireto, BNDES Automático*)[30] (Cunha da Costa 2008). Resolution N° 1.135/2004 established that the commission rate of the *BNDES* varies in function of the inclusion of family farmers into the biodiesel project. For micro, small or medium enterprises holding the social seal, this rate amounts to 1% p.a. instead of the normal rate of 2% p.a. For large enterprises holding the social seal, commission amounts to 2% p.a. instead of 3% p.a. (Banco Nacional de Desenvolvimento Econômico e Social 2004). For projects with a social seal, 90% of the potential supported items may be funded through *BNDES* loans while for projects without the seal this limit is 80% (Banco Nacional de Desenvolvimento 2006). The *BNDES* portfolio, which due to the financing policies includes only large projects and thus not financing of feedstock cultivation, included 11 operations in March 2008, of which 4 received indirect, one mixed and 6 direct financial supports by the *BNDES*. 250 million BRL loans were granted or had been approved for total investments of 308 million BRL with an annual installed biodiesel production capacity of 674 million litres. The projects were concentrated in the Centre-West region, São Paulo and Rio Grande do Sul and did not include any projects in the North or the Northeast (Cunha da Costa 2008). In 2009, *BNDES* biodiesel portfolio summed up to 630 million BRL for investments of 811 million BRL (Cunha da Costa 2009).

[30] The basic interest rates of these two different operational modes are quite similar and include the national long-term interest rate (6.25% p.a.), the commission for the BNDES (1-3% p.a.) and a risk loan rate (0.46 - 2.54% p.a.) in the case of a direct operation with the BNDES or the intermediation rate (0.8% p.a.) and the commission of the financing agent in the case of an indirect operation.

The *Programa BB de Apoio a Produção e Uso de Biodiesel* of the *Banco do Brasil* is an important programme for the support of the cultivation of biodiesel feedstock. The programme manages *BNDES* loans for biodiesel projects and other financing lines for the industrial production of biodiesel like *PRONAF Agroindústria, Prodecoop, FCO Empresarial* and others. But different from *BNDES*, *Banco do Brasil* manages loans for the agricultural production of the raw materials and is one of the principal financing agents for *PRONAF*[31]. The special regulation for biodiesel concerns the granting of an additional cost loan within the same year when planting raw materials that will serve as a feedstock for biodiesel production (Banco Central do Brasil 2008). In 2007, 50 million BRL of loans were provided for cultivation of raw materials for biodiesel production within *PRONAF* (O Povo 2007).

The regional development banks like the *Banco do Nordeste* (*BNB*) and the *Banco da Amazônia* also have special biodiesel programmes, which introduce additional regulations for biodiesel activities within the existing financing programmes. *BNB* grants loans for biodiesel projects through *PRONAF* as well as through the various constitutional funds for the development of the Northeast (e.g. *FNE - Fundo Constitucional de Financiamento do Nordeste; FNE Rural, FNE Agrin, FNE Verde*). To benefit from these loans, applicants must prove that they will cultivate raw materials recommended by the *MAPA* for a certain region, utilise certified seeds, guarantee technical assistance, and guarantee purchase of the feedstock produced. The *Banco da Amazônia* granted loans to 35 farmers in 2005 cultivating palm oil for the biodiesel plant of the company Agropalma and manages the equivalent constitutional fund for the North (*FNO - Fundo Constitucional de Financiamento do Norte*). In 2007, the *Ministério de Integração Nacional* (*MIN*) determined that liberalisation of resources for biodiesel projects originating from the regional funds should be prioritised. Approved financing of the three regional funds (*FNE, FNO and FCO – Fundo Constitucional de Financiamento do Centro-Oeste*) amounted to 9.7 billion BRL in 2007 and since the interest rates are the lowest for rural and industrial investments, these regional funds represent an attractive financing tool (Paula Andrade 2007).

Table 16 – Specific funding programmes for biodiesel investments in Brazil[32]

| Bank | Fund | Applicants | Biodiesel related funded activities | Special biodiesel regulations |
|---|---|---|---|---|
| BNDES, or any accredited bank by BNDES | Direct and indirect funding, BNDES Automático | Micro, small and medium enterprises | Implementation/ expansion of productive capacity, acquisition of national capital goods, every phase of biodiesel production | BNDES commission 1% p.a. (instead of 2% p.a.) for social seal;<br><br>Maximum funding 90% when social seal, 80% without seal |
| BNDES, or any accredited bank by BNDES | Direct and indirect funding, BNDES Automático | Large enterprises | Implementation/ expansion of productive capacity, acquisition of national capital goods, every phase of biodiesel production | BNDES commission 2% p.a. (instead of 3% p.a.) for social seal;<br><br>Maximum 90% funding when social seal, 80% |

[31] Within PRONAF, general effective interest rates for cost loans vary between 1.5% p.a. (loan limit 5,000 BRL) and 5.5% (20,000 - 30,000 BRL) and for investment loans between 1% p.a. (loan limit 7,000 BRL) and 5% p.a. (28,000 - 36,000 BRL).

[32] Listed only financing lines or programmes that have specific regulations for investments in biodiesel production or use. These investments may also be funded through other, more general financing lines or programmes not listed.

| | | | | |
|---|---|---|---|---|
| | | | | without seal |
| BNDES, or any accredited bank by BNDES | FINAME<br><br>FINAME Agrícola<br><br>FINAME Leasing | Micro, small, medium and large enterprises (e.g. transport companies, co-operatives) | Acquisition of national machinery or equipment authorized for use of B20 or higher blends | Amortisation period may be extended for up to 25% of normal period |
| Any bank, accredited by BNDES | PRONAF and sub-programmes | Small farmers registered within PRONAF | Cultivation of raw materials for biodiesel production | Additional second cost loan granted to same conditions within the same year |
| Banco do Brasil,<br><br>Banco do Nordeste,<br><br>Banco da Amazônia | Regional constitutional funds and sub-funds (FCO, FNE, FNO) | Micro, small, medium and large enterprises | Projects related to renewable energy production (biodiesel) | (Prioritising liberalisation of funds for biodiesel projects) |

### 3.2.2.3. Increasing mandatory blend for biodiesel

The increasing mandatory blend for biodiesel can be considered the most important promotion tool since it provides a minimum market for biodiesel producers. According to the law N° 11.097, a 2% vol. mandatory blend should be introduced in January 2008 and a 5% mandatory blend should enter into force by the 1st of January 2013 at the latest. However, the law also empowered the *CNPE* to reduce these periods considering the supply of raw material and the industrial production capacity of biodiesel, the participation of family farmers on feedstock supply, the reduction of regional inequalities, the performance of engines using biodiesel and the policies for industrial and technological innovation (Presidência da República 2005a). Thus in 2005, the *CNPE* authorised a blend of up to 2% vol. from the 1st of January 2006 for biodiesel supplied from producers that were holding the “Social Fuel Seal” and justified this measure with the necessity to induce investments immediately in order to increase the national biodiesel production and supply (Conselho Nacional de Política Energética 2005). The regulatory agency *ANP* was authorised to determine the amount of biodiesel that should be acquired by the diesel producers and the importers and several auctions were realised in 2006 and 2007 (see chapter 3.2.2.4). It was believed that with the start of the general 2% blend from January 1st of 2008, there would not be any more auctions but a price competition between the producers offering biodiesel. However, the resolution *CNPE* N° 5 (03/10/2007) determined that the amount of biodiesel necessary for the 2% vol. blend from January 2008 on should be acquired through public auctions as well. The *MME* established the guidelines and the *ANP* realised these auctions. *CNPE* resolution N° 5 does not change the percentage share or the timetable of the mandatory blend, but it reserves up to 80% of B2 for producers holding the social seal (Conselho Nacional de Política Energética 2007). In March 2008, the *CNPE* raised mandatory blend of biodiesel to 3% vol. from 1st of July 2008 on due to the increasing installed biodiesel production capacity (Conselho Nacional de Política Energética 2008). In July 2009 the 4% vol. blend was introduced and since January 2010, three years before the latest date, a 5% vol. blend is mandatory (Conselho Nacional de Política Energética 2009a; Conselho Nacional de Política Energética 2009b).

Table 17 – Mandatory blending quota in Brazil, 2005-2011 (Presidência da República 2005a; Conselho Nacional de Política Energética 2005; Conselho Nacional de Política Energética 2008; Conselho Nacional de Política Energética 2009a; Conselho Nacional de Política Energética 2009b)

| | Authorised | Mandatory | Social Seal |
|---|---|---|---|
| 01/2005 - 12/2007 | 2 % | - | 2 % |
| 01/2008 – 06/2008 | 5 % | 2 % | 1.6 % |
| 07/2008 – 06/2009 | 5 % | 3 % | 2.4 % |
| Since 07/2009 | 5 % | 4 % | 3.2 % |
| Since 01/2010 | 5 % | 5 % | 4 % |

### 3.2.2.4. Biodiesel auctions with guarantee prices

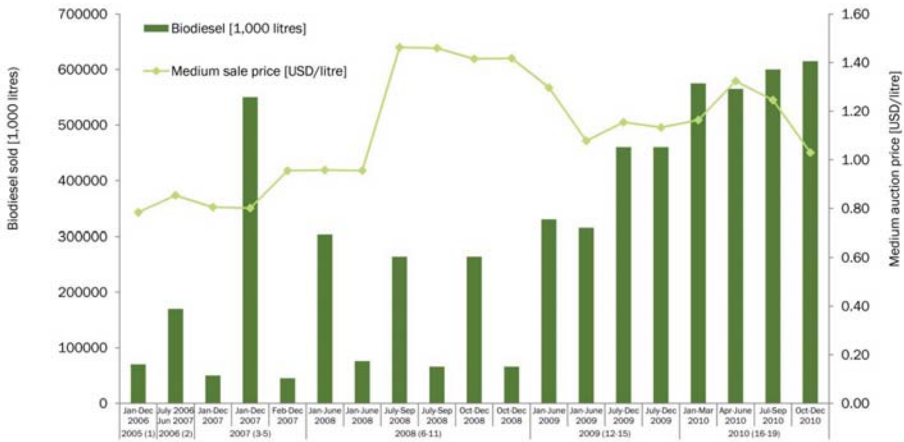


Figure 5 – Biodiesel sold at auctions and medium sale prices 2005-2010 (Giersdorf, based on (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2010f))

Based on the resolutions of the *CNPE*, the regulatory agency *ANP* realises auctions for the biodiesel commercialisation since 2005. Seven auctions were realised until the end of 2007 in which only producers with the social seal or that were in process of approval could participate (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2005). With the beginning of the 2% mandatory blend in January 2008, 80% of the total volume for one period should be open for bids from producers with a social seal and the remaining 20% for any biodiesel producer (see chapter 3.2.2.3). The execution and the general rules of the auctions changed only slightly during the years: In a call for bid, *ANP* publishes the amount of biodiesel that will be acquired by the refineries - that import and/or produce the fossil diesel - according to their market participation[33]. Since ten out of the eleven Brazilian refineries are owned by

[33] The day of the auction, ANP publishes the maximum price (prices are FOB, in tanks, including social contributions (PIS/COFINS), excluding VAT (ICMS)) which in general cannot be surpassed by the offers of the biodiesel producers. During the first seven auctions, these could offer their biodiesel, divided in specified lots, several times during an electronic auction that lasted some hours. At the end of the auction, the offers with the lowest price could be sold to the refineries by the biodiesel producers. For the last auctions, the electronic auction was substituted through an auction where biodiesel producers can offer

Petrobras, the company has to purchase 93% of the total volume while the remaining 7% have to be purchased by the Refinery Alberto Pasqualini - REFAP S/A on which Petrobras holds a 70% share. It cannot be excluded that the maximum prices for biodiesel set by the regulatory agency *ANP* do not only reflect the market conditions (feedstock prices) but also the political goal of increasing biodiesel production and consumption. Due to the increasing biodiesel production capacities and increasing feedstock prices in 2008, the auctions continued even after the beginning of the mandatory blend in order to guarantee revenues for the biodiesel producers, this is also reflected by higher medium auction sale prices during the auctions in 2008 (see figure 5 and table 46 in the annex). Since there is no information available at which prices Petrobras resells part of the biodiesel to the other distribution companies which have to acquire the volumes according to their market participation in the diesel fuel market, it is possible that Petrobras does not pass on completely the expenditure for the biodiesel to the distribution companies in order to minimise increase of diesel fuel prices.

### 3.2.2.5. Differentiated tax reductions for biodiesel

As already described in chapter 3.1.7.3, the ***Contribuição de Intervenção no Domínio Econômico (CIDE Combustíveis)*** is levied on the importation and commercialisation on fuels as an excise duty by the Brazilian federal government. From 2004 to 1st of May 2008, the contribution amounted to 0.07 BRL/litre diesel fuel. On 2nd of May 2008, this contribution was reduced to 0.03 BRL/litre to absorb the increase of the diesel fuel prices at the Brazilian refineries (Presidência da República 2008b). In June 2009, after a while of declining fossil fuel prices, the government announced the reduction of diesel and gasoline prices by Petrobras and increased *CIDE* for diesel to former 0.07 BRL/litre (Carolina Andrade 2009; Presidência da República 2009c). Biodiesel is not mentioned in the basic law that regulates incidence and application of *CIDE* and thus not taxed.

The social contributions ***PIS (Programa de Integração Social e de Formação do Patrimônio do Servidor Público)*** and ***COFINS (Contribuição para o Financiamento da Seguridade Social)*** have already been described (see chapter 3.1.7.3.). Like for gasoline, there exist two forms of paying these taxes for diesel and biodiesel: A non-cumulative tax regime with ad valorem rates and a special regime with excise rates. The ad valorem rates for diesel amount to 4.21% (*PIS*) and 19.42% (*COFINS*) and for biodiesel to 6.15% (*PIS*) and 28.32% (*COFINS*) (Receita Federal 2005). With diesel fuel selling prices at the Brazilian refineries amounting to 1.13 BRL/litre, the ad valorem rate for *PIS/COFINS* would exceed 0.25 BRL/litre for diesel fuel. As in the case of gasoline, current excise rates are lower in order to promote adoption of the special regime by the refineries since it is less bureaucratic. For diesel, these rates amount to 0.02636 BRL/litre (*PIS*) and 0.12164 BRL/litre (*COFINS*) and for biodiesel in general to 0.03889 BRL/litre (*PIS*) and 0.17907 BRL/litre (*COFINS*) (Receita Federal 2005). For biodiesel produced from castor oil or palm oil in the North, Northeast or semi-arid-regions, *PIS* amounts to 0.02703 BRL/l and *COFINS* to 0.12447 BRL/l. Contributions for biodiesel produced from any feedstock acquired from small farmers participating in the *PRONAF* amount to 0.01249 BRL/litre (*PIS*) and 0.05753 BRL/litre (*COFINS*). For biodiesel produced from any feedstock in the North, Northeast and semi-arid regions with the raw material acquired from small farmers participating in the *PRONAF* social contributions are zero[34] (Presidência da República 2004f) (see table 18).

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their lots in two rounds and thus can reduce their bids only once. This change probably took place in order to prevent an excessive price dumping which had occurred due to an oversupply of biodiesel.

[34] Initially, zero taxation was restricted to biodiesel from castor oil and palmoil as a feedstock from farmers within PRONAF in the Northeast, North and Semi-arid. Decree N° 6.458 (14/05/2008) enhanced zero taxation to any feedstock.

The *Imposto de Produtos Industrializados (IPI)* is a federal excise tax for industrialized products. Diesel fuel is exempted from taxation, while biodiesel is not exempted, but actual tax rate is zero (Presidência da República 2006a; Presidência da República 2006b).

Table 18 – Federal taxes on biodiesel and diesel fuel in Brazil, 2010

| | Biodiesel (BRL/litre) | | | | Diesel (BRL/litre) |
|---|---|---|---|---|---|
| Feedstock | Any | Castor or palm | Any | Any | - |
| Region | -- | N, NE, Semi-arid | -- | N, NE, Semi-arid | - |
| Feedstock supplier | -- | Agribusiness | Small farmers (PRONAF) | Small farmers (PRONAF) | - |
| IPI | 0 | 0 | 0 | 0 | Exempted |
| CIDE[35] | Exempted | Exempted | Exempted | Exempted | 0.070 |
| PIS | 0.039 | 0.027 | 0.013 | 0 | 0.026 |
| COFINS | 0.179 | 0.124 | 0.057 | 0 | 0.122 |
| Total | 0.218 | 0.151 | 0.070 | 0 | 0.218 |

With regard to the value added tax *Imposto sobre Circulação de Mercadorias e Serviços (ICMS)*, the same problems as for gasoline and ethanol fuel exist (see chapter 3.1.7.3). For diesel fuel, *ICMS* rate amounts to 17% in 19 Brazilian states. The Federal District, Minas Gerais, Paraná, Rio Grande do Sul, Santa Catarina and São Paulo apply a rate of 12%, Rio de Janeiro 13% and Goiás 18%. For biodiesel, *ICMS* rate of 17% is valid in 22 Brazilian states. São Paulo (18%), Minas Gerais (18%) and Rio de Janeiro (19%) have a slightly higher rate, while in Rio Grande do Sul *ICMS* rate amounts to only 12% (see table 19) (Castro Neto 2007).

Table 19 – ICMS rates on diesel and biodiesel in Brazilian states 2007 (Castro Neto 2007)

| State | Diesel | Biodiesel | State | Diesel | Biodiesel |
|---|---|---|---|---|---|
| Acre | 17% | 17% | Paraíba | 17% | 17% |
| Alagoas | 17% | 17% | Paraná | 12% | 17% |
| Amapá | 17% | 17% | Pernambuco | 17% | 17% |
| Amazônia | 17% | 17% | Piauí | 17% | 17% |
| Bahia | 17% | 17% | Rio de Janeiro | 13% | 19% |
| Ceará | 17% | 17% | Rio Grande do Norte | 17% | 17% |
| Distrito Federal | 12% | 17% | Rio Grande Do Sul | 12% | 12% |
| Espírito Santo | 17% | 17% | Rondônia | 17% | 17% |

35 From 02/05/2008 to 08/06/2009, CIDE amounted to 0.03 BRL/l.

| | | | | | |
|---|---|---|---|---|---|
| Goiás | 18% | 17% | Roraima | 17% | 17% |
| Maranhão | 17% | 17% | Santa Catarina | 12% | 17% |
| Mato Grosso | 17% | 17% | São Paulo | 12% | 18% |
| Mato Grosso do Sul | 17% | 17% | Sergipe | 17% | 17% |
| Minas Gerais | 12% | 18% | Tocantins | 17% | 17% |
| Pará | 17% | 17% | | | |

Compared to the ethanol fuel policies, differentiated tax reductions for biodiesel can not be considered an important promotion tool. First of all, different from ethylic alcohol, biodiesel is not being used as a neat fuel and there is no direct price competition between diesel and biodiesel fuel. Second, since diesel fuel prices in Brazil follow international market prices, notwithstanding some temporal delays, taxes on diesel fuel are relatively low which reduces the possibility to incentive biodiesel consumption via tax reductions. Between May 2008 and June 2009, federal tax burden of biodiesel produced from soy oil in the Centre-West not using raw materials from small farmers was 0.218 BRL/litre and thus even higher than federal tax burden of diesel fuel with 0.178 BRL/litre. Considering that production costs for biodiesel in the North, Northeast or Semi-Arid are higher than in other Brazilian regions, even the zero taxation of biodiesel from these regions represents only a very limited incentive.

### 3.2.2.6. Funding of R&D on biodiesel technologies

*BNDES* as well as *Banco do Nordeste* and other banks are also funding research and development activities in the biodiesel sector. *BNDES* re-launched the technological fund called *FUNTEC* which supports technological development and innovation projects in the field of "renewable energy, in particular the technological developments able to get, in the long-run, an outstanding or leading position for Brazil in this area" (Banco Nacional de Desenvolvimento Econômico e Social 2010a). Technology institutions like universities for instance, research supporting institutions or companies taking part in research can apply for financial support which is granted directly by *BNDES* for up to 90% of the total project value and is non-repayable. In 2007, *FUNTEC* had 31 project in pipeline with 383 million BRL invested and over 600 million BRL total investment (Garten Rothkopf 2007).

Since 1971, Banco do Nordeste has a technological fund (*FUNDECI - Fundo de Desenvolvimento Científico e Tecnológico*) that grants non-repayable support for research and technological diffusion projects which contribute to regional development. In 2007 *FUNDECI* called for proposals which should contribute to the development and diffusion of appropriate agro-energy technology. Within this call, primarily research projects on plant breeding and cultivation techniques of species like castor, jatropha curcas, babassu and sunflower seeds realised by *EMBRAPA* units are being funded (Banco do Nordeste 2007). But the general fund also supports some federal or state universities doing research on the utilisation of biodiesel co-products or quality test methods of biodiesel (Banco do Nordeste 2008).

In order to coordinate and disseminate the results of research projects on biodiesel production and consumption in Brazil, the *MCT* launched the *RBTB - Rede Brasileira de Tecnologia de Biodiesel* (Brazilian Biodiesel Technology Network), which originated from the *PROBIODIESEL* of the *MCT*, in 2004 (Fundação de Amparo à Pesquisa do Estado do Rio de Janeiro 2004). Some of the projects within this network are funded through *MCT's* financing agency *FINEP* and a contribution of the municipal or state financing agency. In 2005 and 2006, two general calls for project proposals on biodiesel production were launched, summing up to financing of 6 million BRL (Financiadora de Estudos e Projetos 2005; Financiadora de Estudos e Projetos 2006). But most of the projects were financed after public calls for proposals had launched by the *Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq)*. Between 2003 and 2005 16 million BRL from the sectoral funds *CT-ENERG*[36] and *CT-PETRO*[37] were invested into biodiesel projects. For 2006 to 2008, 32 million BRL from the sectoral funds *CT-ENERG* and *CT-AGRO*[38] were approved to be invested into the national biodiesel programme (see table 47) (Ministério da Ciência e Tecnologia 2007a). For 2009 and 2010, planned funding should amount to 60 million BRL for biodiesel projects (Ministério da Ciência e Tecnologia 2007b). Funded activities comprise a wide range of the aspects related to the production and utilisation of biodiesel. They include research on genetic engineering of oilseeds, domestication of native and exotic plants and micro organisms (microalgae), development of small-scale biodiesel production, development of technologies for the utilization of biodiesel co- or by-products, qualification of a network of laboratories for biodiesel certification, programme of motor and vehicle tests with biodiesel, and the realisation of technical-scientific cooperation with other countries among others (Ministério da Ciência e Tecnologia 2007b). There are several state and one regional biodiesel programme of the Northeast which grant financial support to research and development projects within the national network (Portal Biodiesel 2010).

### 3.2.2.7. Tariff and non-tariff import barriers (e.g. fuel specifications)

The import tariff for the most common oilseeds amounts to 8% and for the most common vegetable oils to 10%, no matter whether the vegetable oil is raw or was transformed via transesterification and thus can also be called “biodiesel” (see chapter 4.3.1.2 for technical details) (Ministério do Desenvolvimento, Indústria e Comércio Exterior 2010b).

The Brazilian biodiesel standards are based on a variety of factors, including characteristics of the existing diesel fuel standards, the predominance of the types of compression ignition engines[39], the emissions regulations governing those engines, the availability of different feedstocks and the alcohol used in the transesterification process. Since the Brazilian biodiesel specification shall not exclude any feedstock or a technological route, it is not as restrictive as the European biodiesel norm that is applicable only to fatty acid methyl esters and that was based on the experiences with rapeseed methyl ester. In addition to that, the Brazilian standard describes a product that represents a blending component in conventional diesel fuel, while the European biodiesel norm describes a product that can be used also as a neat fuel (Tripartite task force Brazil, European Union & United States of America 2007). The Brazilian biodiesel standard that was established by the regulatory agency *ANP* in 2004 at the beginning of the biodiesel programme was strongly influenced by the European and the US standards for biodiesel. But for many characteristics it did not introduce any limits but the obligation to report the values for these characteristics (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2004b). This measure should help to gather information about the Brazilian biodiesel with a variety of feedstocks because it was unclear whether biodiesel from feedstock other than soy and rapeseed would comply with the specifications used in the US and the EU. However, in March 2008 a new standard implement-

[36] The *CT-ENERG* fund finances programmes and projects in the energy sector, which aim at end-use efficiency and the development of alternative energy sources. The fund receives 0.75-1% of the income of electric energy generation, transmission and distribution companies.
[37] The *CT-PETRO* was created in 1999 to stimulate innovation in the production of oil and natural gas. The fund receives 25% of any excess of 5% oil and gas royalties.
[38] THE *CT-AGRO* focuses on the scientific capacity and technology creation in the area of agronomy and encourages investment in biotechnology. The fund receives 17.5% of CIDE, imposed on the production and importation of fuels.
[39] Diffferent from Europe, there are no passenger cars with compression ignition engines in Brazil since it is forbidden by law.

ed specifications for almost every characteristic and these specifications are very similar to those described in the European standard EN 14214 (see table 20) (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2008b). Thus, Brazilian biodiesel fuel specification can not be interpreted as a non-tariff import barrier and a tool to protect domestic biodiesel production.

Table 20 – Comparison of biodiesel specifications in Brazil and the EU (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2008b)

| Property | Unit | ANP N° 7 (19/3/2008) | EN 14 214 |
|---|---|---|---|
| Density at 20°C | kg/m³ | 850-900 | 860-900[40] |
| Cinematic Viscosity at 40°C | Mm²/sec | 3,0-6,0 | 3.5-5.0 |
| Water Content, max. | %mass | 500 | 500 |
| Total Contamination, max. | mg/kg | 24 | 24 |
| Flash Point, min. | °C | 100 | 120 |
| Ester Content, min | %mass | 96.5 | 96.5 |
| Carbon residue, max. (on 100% sample) | %mass | 0.050 | -- |
| Sulphated Ash, max. | %mass | 0.020 | 0.020 |
| Sulphur content, max. | mg/kg | 50 | 10 |
| Group I metals, max. (Na + K) | mg/kg | 5 | 5 |
| Group II metals, max. (Ca + Mg) | mg/kg | 5 | 5 |
| Phosphorous content, max. | mg/kg | 10 | 10 |
| Copper strip corrosion | Rating | Class 1 | Class 1 |
| Cetane number, min. | | Report | 51.0 |
| Cold Filter Plugging Point, max. | °C | 19[41] | -20/+5 |
| Acid number, max. | mg KOH/g | 0.50 | 0.50 |
| Free Glycerol, max. | %mass | 0.02 | 0.02 |
| Total Glycerol, max. | %mass | 0.25 | 0.25 |
| Monoacylglycerol, max. | %mass | Report | 0.80 |
| Di-, and Triacylglycerol, max. | %mass | Report | 0.20 |
| Methanol or Ethanol content, max. | %mass | 0.20 | 0.20 |
| Iodine Value, max. | G iodine/100 g | Report | 120 |
| Oxidation stability, 110°C, min. | Hours | 6.0 | 6.0 |
| Linolenic Acid Methyl Ester, max. | %mass | -- | 12.0 |
| Polyunsaturated Methyl Esters, max. | %mass | -- | 1 |

[40] Density at 15°C
[41] Only for the regions South, Southeast, Centre-West and the state of Bahia. For the other regions, it has to be reported.

Since biodiesel is primarily used as a blending component of conventional diesel fuel in Brazil, it is also important to compare the existing standards for conventional diesel fuel. The only remarkable difference is that while European diesel is virtually sulphur-free since January 1st 2009, Brazilian standard allows much higher limits although a low-sulphur diesel is offered in some metropolitan regions since 2009 (see table 48 in the annex for more details). But the reduction of sulphur content of diesel is driven by emission control policies and does not represent an important non-tariff import barrier either. Since biodiesel has a high lubricity it can substitute sulphur in conventional diesel and help reduce emissions without the necessity of additives and thus emission control policies can rather promote than obstruct biodiesel production and consumption.

### 3.2.3. Conclusion

There are several tools that shall promote biodiesel production and consumption. Different from ethanol policies, biodiesel policies focus more on the conversion of the agricultural biomass to biodiesel and less on the consumption of the biofuel. Feedstock cultivation and biodiesel production in general and especially by small farmers are supported via credit guarantees and the biodiesel auctions can be considered “feed-in-tariffs” for biodiesel. Several programmes also support R&D in biodiesel feedstock cultivation and production technologies. This focus on the production of the biofuel is also due to the fact that biodiesel industry and the whole production chain still has to be built up, while ethanol production and consumption is already well established. Thus, while in the case of ethanol, differentiated tax treatment represents a very important promotion tool to increase competitiveness of ethanol fuel, this incentive is not very important for biodiesel since it is not used as a neat fuel.

Table 21 – Public support policies for biodiesel production and consumption in Brazil

| Biofuel well-to-wheel chain | Objective | Measures | Biodiesel |
|---|---|---|---|
| Conversion of agricultural biomass | Reduction of infrastructure costs | Credit guarantees | Several programmes (BNDES, BB, etc.) |
| | Guaranteed price for biofuel | “feed-in-tariff” | Prices for biodiesel set for auctions |
| | Minimum market participation | Quota obligation scheme | Preferential treatment of some feedstock and family farmers |
| Biofuel consumption | Reduction of biofuel prices | Fuel excise tax exemption | Differentiated reduction of CIDE and PIS/COFINS |
| | | VAT exemption | ICMS reduction in some states |
| | Minimum market participation | Quota obligation scheme | Mandatory blending of 5% |
| Overall | Commercial development of biofuel technologies | (R&D) support schemes | Several federal and state programmes |

| | | | |
|---|---|---|---|
| | Protection of domestic biofuel industry | tariffs on biofuel imports | 10% on biodiesel |
| | | imports tariffs on commodities | 8% on oilseeds,10% on vegetable oils |

# 4. Production, distribution, and consumption of liquid biofuels in Brazil

## 4.1. Liquid biofuels within the Brazilian transport sector

In the past years, Brazil invested heavily in offshore extraction technology and increased national oil production constantly through its oil company Petrobras. When in 2006 Brazilian president Luiz Inácio Lula da Silva inaugurated the platform P-50 in the South Atlantic, Brazil became theoretically independent from oil imports and celebrated this achievement as “self-sufficiency” (Spitz 2006). However this self-sufficiency does not mean the absence of any crude oil flows at all. With a production of 119.2 million m³, Brazil exported 36.6 million m³ and imported 19.7 million m³ of crude oil in 2010 (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2011a). Since the Brazilian refineries were built when Brazil still imported most of its oil supply from the Middle East, their efficiency is better with these light crude oil sorts than with the Brazilian sorts that have different chemical-physical characteristics. Therefore, Brazil is forced to export part of its heavy crude oil (636 USD/m³ FOB, 2012) and to import more expensive light crude oil (742 USD/m³ FOB, 2012) (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2013).

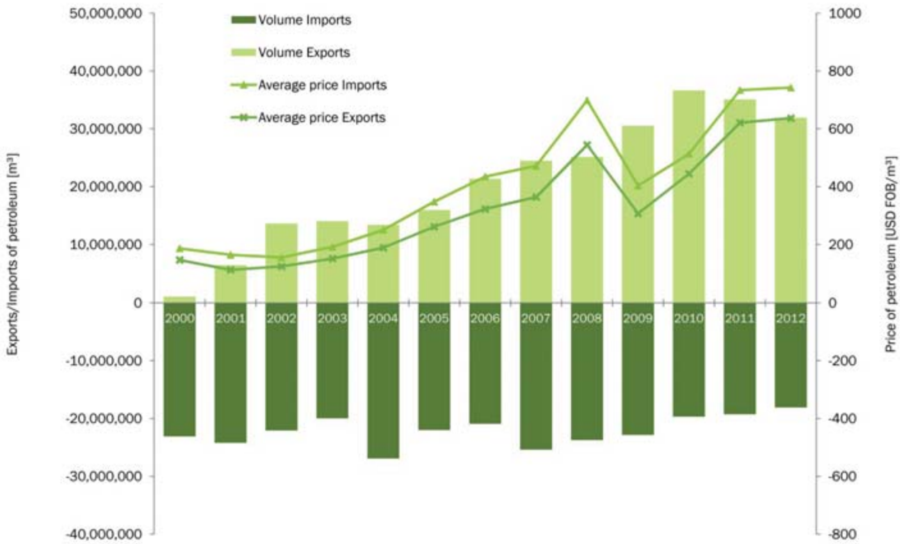


Figure 6 – Brazilian imports and exports of crude oil 2000-2012 (Giersdorf, based on (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2013))

11 of the 13 Brazilian refineries are owned by Petrobras which virtually holds a monopoly in crude oil refining with 98.5% of the national refining capacity. These refineries processed 106.3 million m³ crude oil in 2010, of which 19% were imported (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2011a). The refining structure of these refineries in 2005 was the following: 9% naphtha, 20% gasoline,

9% LPG[42], 5% kerosene, 41% diesel fuel and 16% heavy heating oil (Empresa de Pesquisa Energética 2006). Through a continuous investment in refineries e.g. adding hydro treatment facilities, Petrobras further wants to change the output ratio of heavy, middle and light derivates in order to produce less heating oil and more diesel fuel and gasoline, because diesel fuel demand exceeds diesel fuel production year by year. In 2012, diesel fuel consumption was about 56 million m³, which forced Brazil to import 8 million m³ and to export 0.3 million m³ of diesel fuel (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2013). The comparatively high demand of diesel fuel reflects the Brazilian transport infrastructure which primarily relies on buses and trucks for passenger and freight traffic (see figure 7). The need of considerable diesel fuel imports was one of the factors that motivated the introduction of the biodiesel programme in 2004.

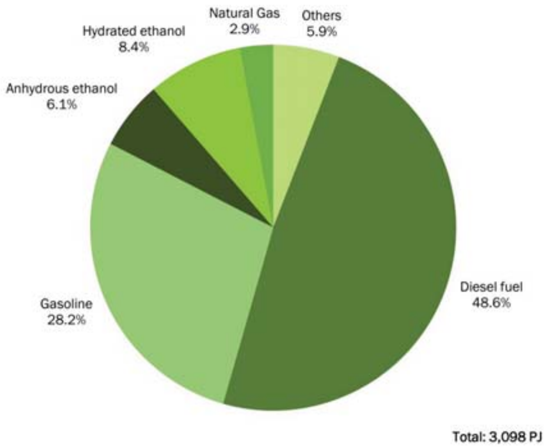


Figure 7 – Fuel consumption in Brazilian transport sector 2011 (Giersdorf, based on (Empresa de Pesquisa Energética 2012, 79))

Different from fossil energy sources such as gasoline and diesel fuel that result from geological processes that took million of years, ethanol and biodiesel are renewable fuels, which can be produced from biomass. Basic for all biomass is the photosynthetic process in which carbon dioxide is transformed into the monosaccharide glucose and oxygen under the influence of light, water and chlorophyll. Plants use the monosaccharide glucose to build disaccharide such as sucrose that is commonly called “sugar”, or polysaccharide such as starch, or fatty acids through further assimilation processes. Both sugar and starch containing plants or oilseeds and animal fats can be converted into ethanol or biodiesel through thermo-chemical, physical-chemical or biochemical processes (Hartmann and Kaltschmitt 2003). The prefix "bio" refers to the origin of the raw material and not to its mode of production, as often interpreted erroneously (Henniges 2007). Alternative denominations such as „agrofuels“ have a narrower focus, as they exclude effluent water, organic waste, algae, etc. from which biofuels can be made as well. For this reason the established terms „biofuels“, „ethanol“ and „biodiesel“ will be used in this work.

[42] Liquefied petroleum gas (LPG) is manufactured during the refining of crude oil, or extracted from oil or gas streams as they emerge from the ground. It is a mixture of hydrocarbon gases, mainly propane and butane. Although it can be used as a fuel for vehicles (then called Autogas), 80% of Brazilian LPG is consumed as a cooking fuel in virtually (95%) all Brazilian households.

## 4.2. Ethanol production, distribution, and consumption in Brazil

### 4.2.1. Production of ethanol in Brazil

#### 4.2.1.1. Sugarcane cultivation in Brazil

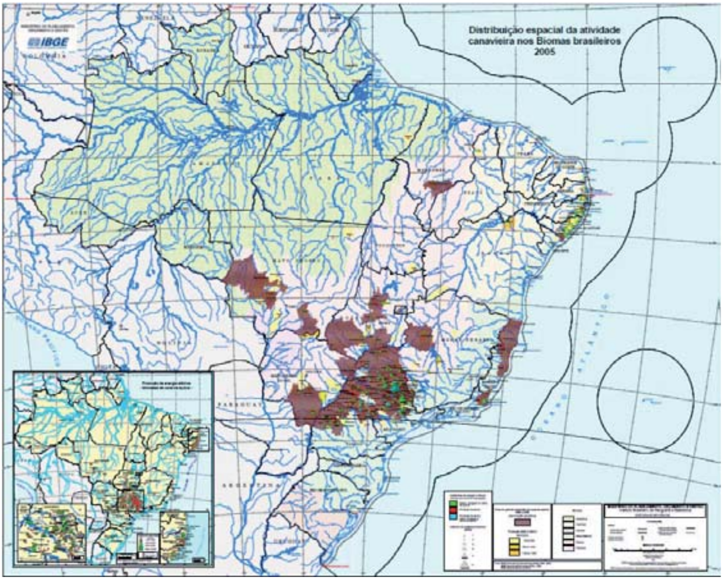


Figure 8 – Spatial distribution of sugarcane plantations in Brazil in 2005 (Instituto Brasileiro de Geografia e Estatística 2006b)

Sugarcane originates from South Asia but is cultivated throughout the tropics from the latitude 35° N to 35° S. As a C4 plant, sugarcane is considered highly efficient in converting radiation energy into chemical energy and the high biomass production is due to its elevated leaf area index[43]. Temperatures between 21° C and 26° C can be considered as optimal for sugarcane, while temperatures above 38-40° C inhibit most of the physiological activities and temperatures below 21° C diminish the stalks' growth and promote accumulation of the sucrose (João Domingos Rodrigues 1995). Hydrological deficit may vary between 10 mm/year and 250 mm/year, a dry season is needed for maturation and harvesting of sugarcane. Brazil is located between 5° N and 34° S latitude and therefore dominated by tropical climate. Sugarcane is being planted in the Northeast with its humid coastal climate and in the continental Southeast and Central-West which is dominated by tropical climate with dry winters and humid summers (1,500 mm/year) and temperatures between 20° C and 24° C. Sugarcane cultivation in Brazil is based on a ratoon-system, which means that the same plant is cut five or six times before it has to be renovated and substituted by a new plant. Harvesting season is from May till November in the Central-South and from September till March in the Northeast. This can be explained by regionally different

[43] The Leaf Area Index is the ratio of total upper leaf surface of vegetation divided by the surface area of the land on which the vegetation grows.

occurrence of dry seasons in which the sugarcane is being harvested. It is common to burn down the cane (dry leaves) before harvesting to kill dangerous animals and to reduce costs of manual harvesting and of transportation. After burning the cane, it has to be harvested, transported and processed within 36 hours in order to minimise acidification and further losses of sucrose content. Therefore sugar and ethanol plants possess their own trucks to transport the cane to their mills and the medium distance between the sugarcane plantations and the mill rarely exceeds 20 km (Schmitz 2005).

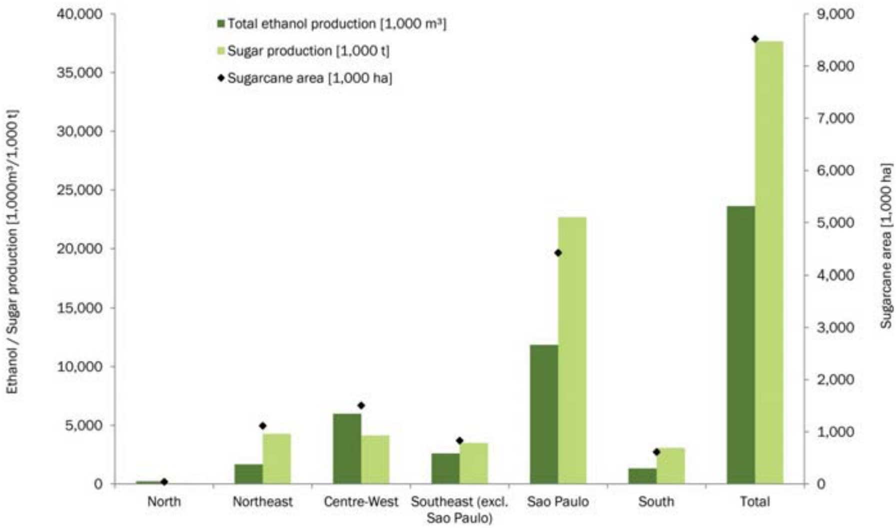


Figure 9 – Sugarcane area and ethanol and sugar production in Brazil 2012/13 (Giersdorf, based on (Companhia Nacional de Abastecimento 2012))

Historically, sugarcane production in Brazil was concentrated in the states of the Northeast, where sugarcane had been introduced in 1532 by Portuguese colonizers to produce sugar for the European market. During the 16th and 17th century, sugar was the most important export product and sustained the Brazilian economy. As sugarcane lost significance and coffee became the principal export product during the 18th and 19th century, the demographic and economic centre shifted to the states of São Paulo and Rio de Janeiro. Only during World War II, the sugar production of the Northeast lost its important supply function for the international and Brazilian market, when submarine war restrained shipping traffic. The sugar producers from São Paulo successfully lobbied for increased production quotas in the 1940s and 1950s, which were regulated by the *Instituto de Açúcar e Álcool* (*IAA* - Institute for Sugar and Alcohol) (Szmrecsányi and Pestana Moreira 1991). In 1948/49 Pernambuco (5 million tons) and São Paulo (4 million tons) contributed most to the Brazilian sugarcane production of 15.6 million tons. The alcohol programme reinforced the concentration of the sugar and ethanol complex in São Paulo and at least half of the Brazilian sugarcane has been harvested in this state every year since 1984/85. In 2012/13, 52% of the Brazilian sugarcane were planted in São Paulo and 60% of the ethanol and 50% of the sugar were produced in this state (see figure 9). Beside São Paulo, only Goiás, Minas Gerais, Paraná and Mato Grosso do Sul produced more than one billion litres of ethanol and only Minas Gerais, Paraná, Alagoas, Goiás, Pernambuco and Mato Grosso do Sul produced more than 1 million tons of sugar in 2012/13 (see table 49 in the annex). Because of the proximity of the ports of the Northeast to important export markets, the share of most of these states on Brazilian sugar production is relatively higher than on ethanol production. On the other side, in the land-locked states of the Central-West that recently started to produce primarily ethanol, sugar production is of lesser importance.

### 4.2.1.2. Processing of sugarcane to ethanol and sugar

Traditionally sugar and ethanol are being produced in a combined production process (see figure 10). First of all, the sugarcane is washed to remove organic material from the field and then fed to a set of four to seven mill combinations which extract the juice and the bagasse, the fibre residue. The bagasse contains one third of the sugarcane energy and is used as boiler fuel. Modern efficient boilers not only supply enough electricity and steam for the whole process to be self-efficient but also electricity that can be delivered to the public grid. The cane juice is filtered and treated by chemicals, pasteurised and filtered again. Then the evaporation process increases the sugar concentration of the juice from 14-15° Brix up to 50-58° Brix. Cooling or boiling crystallisation leads to a mixture of clear crystals with a concentration of 91-93° Brix and molasses. Molasses is removed by centrifugation and the sugar crystals are washed by addition of steam and dried by airflow (Smeets et al. 2006).

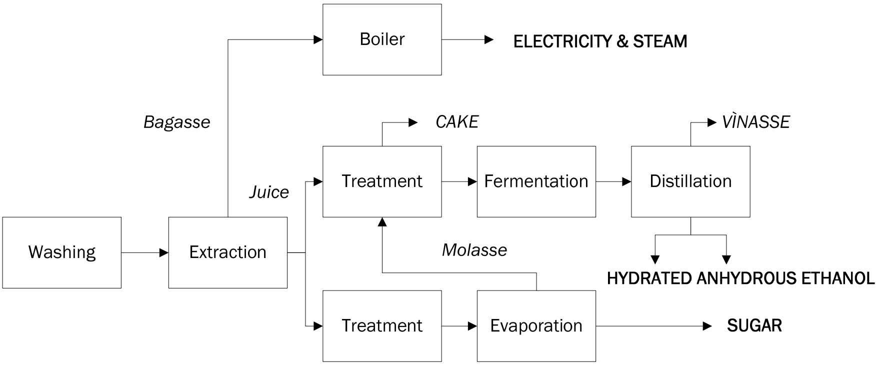


Figure 10 – Simplified overview of the industrial sugar and ethanol production process (Smeets et al. 2006)

This process can be repeated until the molasses is not supersaturated anymore containing less than 50% sugar crystals. It either can be sold as cattle feed or used as an input for alcohol production. In the latter, the molasses is fermented by addition of yeast and after four to twelve hours results in a fermented wine with alcohol content of 7 to 10% vol. The wine is centrifuged to recover the yeast and then boiled and distilled to separate the alcohol from the main resting solid components such as yeast, non-fermentable sugars, minerals and gases ($CO_2$, $SO_2$). This leads to a ethanol-water-mixture with a concentration of 82 to 87% vol. and vinasse, a fluid rich in organic compounds[44]. The ethanol-water-mixture can be concentrated up to 92 to 96% vol. through rectification. This ethanol is called “hydrated ethanol” because of its water content and is widely used in Brazil as a fuel in especially adapted alcohol cars

[44] For every liter of ethanol, 11 litres of vinasse with a high organic load (BOD of 175 g/l) and a pH of 4-5, are being produced during the distillation process (Smeets et al. 2006). Thus, it is highly polluting and its decomposition requires high levels of oxygen. The most common disposal mechanism for vinasse (mixed with waste water from the distillery) is ferti-irrigation, the distribution of vinasse in the sugarcane fields.

since 1980 and flexible-fuel vehicles since 2003. To add ethanol to gasoline for use in spark ignition (Otto) engines, the ethanol has to be virtually free of water and therefore to be dehydrated. In Brazil, this is normally done by addition of the solvent cyclohexane, since the less energy intensive dehydration process using molecular sieves requires higher investment costs (Schmitz 2005). The resulting alcohol is called “anhydrous ethanol” and has an ethanol content of 99.3 to 99.7% vol. Ethanol can also be produced by direct fermentation of the cane juice, the further steps being the same as described above. Since ethanol production from molasses normally does not exceed 11 litres of ethanol per ton of sugarcane, Brazil is using cane juice to a great extent to supply the elevated demand for ethanol fuel since *PROÁLCOOL*.

### 4.2.1.3. Development of sugarcane, ethanol and sugar production

Brazil is by far the biggest sugarcane producer worldwide. Only India reaches a similar sugarcane production but produces primarily sugar for domestic consumption (see table 22).

Table 22 – Top ten sugar producing countries in 2011 (FAOSTAT 2012; United States Department of Agriculture 2012a)

| Country | Sugarcane production (t) | Harvested area (ha) | Sugar production (t) |
|---|---|---|---|
| Brazil | 717,462,000 | 9,076,720 | 36,150,000 |
| India | 293,200,000 | 4,170,000 | 28,800,000 |
| China | 111,454,359 | 1,695,228 | 12,341,000 |
| Thailand | 68,807,800 | 977,956 | 10,235,000 |
| Mexico | 50,421,600 | 703,943 | 5,351,000 |
| Pakistan | 49,372,900 | 942,870 | 4,520,000 |
| Australia | 31,457,000 | 405,000 | 3,900,000 |
| Indonesia | 24,450,000 | 336,000 | 1,830,000 |

In 2010/11, sugarcane was planted on 8.1 million ha in Brazil with a total production of 651 million tons of sugarcane (Companhia Nacional de Abastecimento 2010b). Since the beginning of the alcohol program in 1975, when sugarcane was planted on 1.9 million ha with a total production of 89 million tons, sugarcane production increased 5.9% and the cultivation area 4.2% annually. Due to innovations in plant fertilising and treatment and the development of applied plant varieties, agricultural productivity grew 1.6% annually since 1974/75 and rose from 47 tons of sugarcane per ha to 82 tons of sugarcane per ha in 2009/10[45]. Even though this represents a considerable improvement of agricultural yields, regarding the sheer quantities of sugarcane production it should be kept in mind that more than two third of increased sugarcane production since the beginning of *PROÁLCOOL* in Brazil was achieved through expansion of sugarcane planted area (Schmitz 2005) (see figure 11 and table 23).

[45] In 2012/13 sugarcane was planted on 8.5 million hectars with a sugarcane production of 595 million tons, agricultural yields had declined to 70 t/ha. This may be due to the expansion of sugarcane cultivation in areas with lower productivity, the lower yields due to the mechanization that demands larger distances between the sugarcane rows, lack of renovation of the sugarcane, etc. Thus, the agricultural productivity is not necessarily linearly increasing. The yields also vary largely between the different regions. While in 2012/13 sugarcane yielded 74 tons/ha in São Paulo it only yielded 51 tons/ha in the Northeast (Companhia Nacional de Abastecimento 2012).


Figure 11 – Harvested area and sugarcane production in Brazil 1974/75-2012/13 (Giersdorf, based on (Ministério da Agricultura, Pecuária e Abastecimento 2007a; Companhia Nacional de Abastecimento 2012)

Since the production volumes of sugar and ethanol not only depend on the amount of sugarcane but also on the quality of the sugarcane and of the technological process used to exploit this quality, efforts have been undertaken to improve the characteristics of the sugarcane and to optimise the extraction, crystallisation and fermenting processes as well. The most important variables that determine the sugarcane quality are the apparent sucrose content[46], the fibre content[47] and the purity[48] of the cane. A high sucrose content, a low fibre content and few impurities (low percentage of reducing sugars) lead to a desirable overall high value that expresses the theoretical recoverable sucrose content (TRS) of the sugarcane. The techniques to measure the single parameters and the equitation used to calculate the value are of a great relevance since remuneration of the sugarcane delivered by third parties to the sugar and ethanol mills are based on these calculations (Burnquist 1999, 15). The theoretical recoverable sucrose content of the Brazilian sugarcane increased almost 1% annually during the last 30 years. In 1974/75 it amounted to 109 kg per ton of sugarcane, and reached 142 kg per ton of sugarcane in 2008/09[49] (Ministry of Agriculture, Livestock and Food Supply 2009, 14 f). The industrial process of sugarcane extraction, fermentation and distillation to produce ethanol has been optimised through the introduction of new technologies and the equipment capacities increased in the past 30 years. As a result, the extraction yield increased from 93% to 97%, the fermentation yield from 80% to 90% through the use of continuous fermentation and the distillation yield increased from 98% to 99,5% (Olivério 2006).

Table 23 – Increase of sugarcane production as a result of area and productivity increase between 1974/75 and 2009/10 (Ministério da Agricultura, Pecuária e Abastecimento 2007a; Companhia Nacional de Abastecimento 2009a)

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46 Expressed in pol%/sugarcane and determined by the single or direct polarisation method.
47 The water-insoluble matter of cane and bagasse from which the brix-free water has been removed by drying.
48 The percentage ratio of sucrose (or pol) to the total soluble solids (or brix) in a sugar product. Other soluble solids may be reducing sugars such as glucose and fructose.
49 Despite this general trend, TRS may differ considerably between harvests, since this content is very sensitive to climatic conditions.

| | 1974/75 | 2009/10 | Annual increase |
|---|---|---|---|
| Sugarcane area | 1.9 mio ha | 7.4 mio ha | 4.0 % |
| Sugarcane productivity | 47 t/ha | 82 t/ha | 1.6 % |
| Sugarcane production | 89 mio t | 664 mio t | 5.6 % |

Due to the improved theoretical recoverable sucrose content of the sugarcane and the optimised industrial productivity, the ethanol productivity increased from 66 litres during *PROÁLCOOL* up to 86 litres of ethanol per ton of sugarcane if no sugar is produced from the cane juice. Considering that the agricultural productivity rose from 47 tons of sugarcane per ha in 1974/75 to 79 tons of sugarcane per ha in 2009/10, the yield of ethanol per hectare more than doubled from 3,100 litres per ha at the beginning of *PROÁLCOOL* up to 6,800 litres of ethanol per hectare nowadays (see table 24).

Table 24 – Increase of ethanol productivity between 1974/75 and 2009/10 (Giersdorf)

| | 1974/75 | 2009/10 | Annual increase |
|---|---|---|---|
| Sugarcane productivity | 47 t/ha | 82 t/ha | 1.6 % |
| TRS content | 109 kg/t | 142 kg/t | 0.7 % |
| Ethanol productivity | 3,100 l/ha | 6,800 l/ha | 2.3 % |

Out of the 426 ethanol and sugar mills in Brazil, 249 produced sugar and ethanol in a combined process, 161 plants exclusively ethanol and 16 plants exclusively sugar in 2009/10 (Ministério da Agricultura, Pecuária e Abastecimento 2010b). To describe the Brazilian ethanol – and sugar – production it is useful to analyse the output relation of these two products and the recent trend in this production mix since there is some flexibility to change this mix in most of the plants. Traditionally, ethanol is produced as a by-product of the sugar production, since the theoretical recoverable sucrose content of the sugarcane is used in an optimised way. This explains while most of the Brazilian plants produce sugar *and* ethanol.

When analysing typical Brazilian output ratio of sugar and ethanol, it should be considered that industrial efficiency and output relation differ from plant to plant and from region to region. But due to the need to establish a remuneration system for the sugarcane providers, the *Conselho dos Produtores de Cana-de-Açúcar, Açúcar e Álcool do Estado de São Paulo* (*CONSECANA* - Council of the Sugarcane, Sugar and Ethanol producers of the state of São Paulo) publishes a manual with equivalencies that have to be used because they represent the average output ratio of all mills in São Paulo state. These equivalencies specify the theoretical recoverable sugar content (TRS) of sugar with 1.0495 kg TRS per kg of sugar, of anhydrous ethanol with 1.8169 kg TRS per litre of ethanol and of hydrated ethanol with 1.7409 TRS per litre of ethanol. This data can be used to calculate sugar and ethanol output for one ton of Brazilian sugarcane. During 2005/06 harvest for example, Brazilian sugarcane had a TRS of 145.31 kg per ton of sugarcane. Assuming 40% purity of molasses, there could be produced 120.58 kg of sugar and 10.33 litres of residual anhydrous ethanol <u>or</u> 10.78 litres of residual hydrated ethanol (Conselho dos Produtores de Cana, Açúcar e Álcool do Estado de São Paulo 2005). This means that sugarcane yields 87% sugar and 13% ethanol in this combined production process. This was exactly the nationwide output ratio in Brazil before the beginning of the alcohol program in 1975 (Ministério da Agricultura, Pecuária e Abastecimento 2007a). Due to the growing demand of ethanol fuel during

*PROÁLCOOL*, this ratio changed strongly and reached its peak in 1989 with 73% of the sucrose content used for the ethanol production. During 2012/13 harvest, 51% (299 million tons) of the sugarcane were used to produce about 24 billion litres of ethanol and 49% (294 million tons) to produce about 38 million tons of sugar (Companhia Nacional de Abastecimento 2012).


Figure 12 – Sugar and ethanol production in Brazil 1974/75-2012/13 (Giersdorf, based on(Ministry of Agriculture, Livestock and Food Supply 2009; Companhia Nacional de Abastecimento 2012))

### 4.2.2. Distribution of ethanol in Brazil

For logistical reasons, the ethanol production facilities are located close to the sugarcane fields and not necessarily coincide with the densely populated consumer centres. Partly, the ethanol has to be transported over long distances, since 25-30% of the ethanol has to be transported from the producing states (São Paulo, Paraná, Minas Gerais, Mato Grosso, Mato Grosso do Sul, Goiás, Pernambuco and Alagoas) to the states that do not produce any or not enough ethanol to be auto-sufficient (Procana 2006). By law the 410 ethanol producing plants are not permitted to sell the ethanol directly to final consumers so they have to sell it to the distribution companies, which are collecting the fuel at ethanol collection centres or at their 27 primary or 47 secondary bases. Petrobras has nine collection centres, while other distribution and logistic companies (COSAN, ALL) recently announced investments into collection centres in order to increase feasibility of railroad transport (Mattos 2009; Galcino 2008). Long-distance transports (> 300 km) between the collection and distribution centres are most feasible realised by pipelines, waterways and railroads, but due to an insufficient infrastructure some cost-intensive ethanol flows (4% of supply to retail stations) with a distance above 500 km are done by tank trucks. Pipeline transportation was widely used before the liberalisation of the petroleum and gas sector (3 billion litres ethanol in 2001) by the Petrobras subsidiary Transpetro, but this amount decreased dramatically (1 billion litres ethanol in 2006). Short-distance transports from the ethanol plants to the primary bases of the distribution companies are carried out completely by tank trucks with a medium distance of 200 km. Transfer flows between distribution bases are realised by railroads, trucks and vessels and distribution to the retail and gasoline stations is done entirely by tank trucks with short distances travelled (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2007a).

Due to the insufficient infrastructure to transport large quantities of ethanol from the "new" production regions in the Centre-South and the increasing international demand for ethanol fuel, several pipeline projects were initiated in the last years. Already in 2004, Petrobras announced that the first segment of a pipeline between Goiás, São Paulo and Rio de Janeiro should start operation in 2010 (see figure 36 in the annex), but construction of the first pipeline transporting exclusively ethanol was postponed several times[50] (Barboza 2008; Góes 2010). Considering that transport costs for 1,000 litres of ethanol from the refinery of Paulínia/São Paulo to the 522 km distant refinery of Duque de Caxias/Rio de Janeiro amount to 90 BRL (46 USD) by truck and only 51 BRL (26 USD) by pipeline, transport costs could be reduced significantly assuming minimum amounts of ethanol exports (Scaramuzzo, Bettina Barros and Ivo Ribeiro 2007). Studies analysing the feasibility of the construction of a ethanol pipeline between the state of Mato Grosso (Terminal Cuiabá/Mato Grosso) and the port of Paranaguá/ Paraná, passing the terminal of Campo Grande/Mato Grosso do Sul and the refinery of Paraná in Curitiba/Paraná (REPAR) were studied as well. In 2008, the three largest Brazilian ethanol and sugar producers Cosan, Crystal-Sev and Copersucar announced the construction of a pipeline and created the company Uniduto in 2008 (Bioenergy Business 2009; Uniduto 2010). This pipeline shall connect the most important Brazilian sugar region around Riberão Preto/São Paulo to the refinery of Paulínia and to the port of Santos, where Cosan, CrystalSev, Nova América and Cargill are already operating a terminal exclusively for ethanol exports. However, after the decrease of ethanol exports and the economic crisis, Petrobras and the sugar and ethanol producers represented in the Uniduto company announced in 2010 that they would work together to implement the first ethanol pipeline in Brazil with investments exceeding 2 billion USD (Scaramuzzo and Batista 2010). A second pipeline project that shall connect the region at the division of Mato Grosso and Goiás to the Petrobras pipeline in Ribeirão Preto, SP is being developed by the company ETH Bioenergia, a subsidiary of the business conglomerate Odebrecht (Agência Estado 2010).

With regard to the distribution to the final consumer, there are 202 distribution companies in Brazil due to some peculiarities in the commercialisation chain of the hydrated ethanol (SINDICOM 2010a). The big distribution companies traditionally buy the ethanol using contracts with fixed prices, while the small distribution companies buy ethanol from the plants at the current daily price. Especially in São Paulo there are a lot of distribution companies that buy at lower prices than the big and well-known distribution companies and offer lower prices for the final consumers. Thus, while in gasolina C sales, the large distribution companies that are assembled in the association of the distribution companies SINDICOM[51] hold about 75% of the market share, their share of the hydrated ethanol market did not surpass 60% in the past years (see figure 13). However, this may be also due to tax evasion and other illegal practices

[50] Petrobras holds 10,000 km of pipelines, of which a pipeline of 2,000 km extension between the state of Goiás in the Centre-West (Terminal Senador Canedo/Goiás) and Guanabara bay in Rio de Janeiro (Maritime terminal Ilha D'Água/Rio de Janeiro) connects important ethanol producing regions with refineries and a port. The main purpose of this pipeline is to exchange gasoline and diesel fuel between two refineries on the way (Paulínia/São Paulo (REPLAN), Duque de Caxias/Rio de Janeiro (REDUC) and to transport oil derivates from the refineries into the Centre-West region. Although this pipeline can be used for the transport of ethanol in the contrary direction, Petrobras started to project the construction of a parallel pipeline for the exclusive transport of ethanol. In addition to the construction of a parallel pipeline between the Centre-West and the Terminal Guararema/São Paulo and the enlargement of the pipeline between Guararema and Ilha d'Água, the terminal Guararema will be connected to the maritime terminal of São Sebastião/São Paulo – which can receive extra large ships – and the refinery of Paulínia will be connected to the waterway terminal at the Tietê river in São Paulo. The connection of the Tietê waterway to the ethanol pipeline would facilitate the transport of ethanol from western São Paulo and even western Paraná and Minas Gerais since the Tietê river joins the Paraná river, one of the most important waterways in Brazil, with São Paulo.

[51] Sindicato Nacional de Empresas Distribuidoras de Combustíveis e Lubrificantes. It represents the distribution companies Petrobras BR, Ipiranga, Shell, BP, Repsol, ChevronTexaco, Castrol, Esso (Cosan), AleSat, Total, FIBrasil and Sabbá.

of which smaller distribution companies were repeatedly accused by SINDICOM[52] in the past. Fictitious ethanol transactions between different states, the addition of solvents to gasoline and of water to the anhydrous ethanol in order to sell it as hydrated ethanol are activities that some distribution companies used to offer fuels at lower prices. But recurrent control activities by federal and state agencies as well as changes in the fuel legislation helped to reduce supposed frauds and to increase market shares of SINDICOM associates' sales of hydrated ethanol (Reuters 2008).

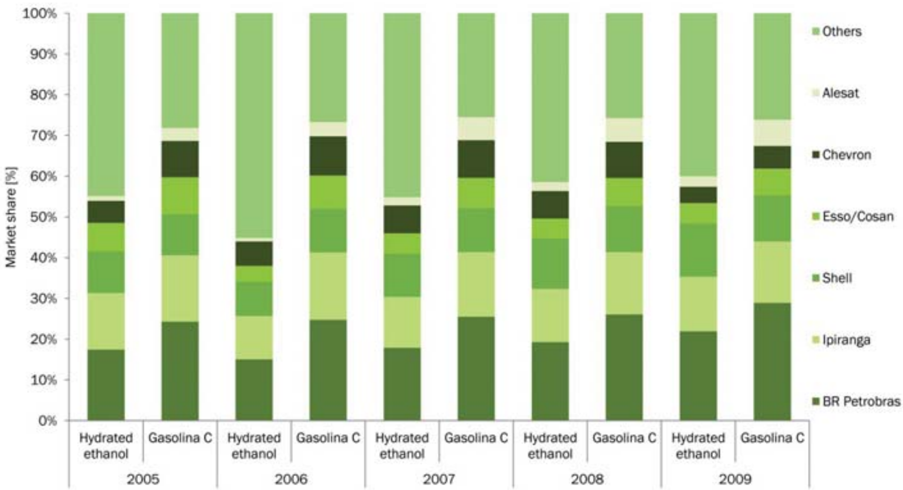


Figure 13 – Market shares on hydrated ethanol and Gasolina C sales of fuel distribution companies in Brazil 2005-2009 (Giersdorf, based on (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2006a; Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2007b; Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2008a; Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2009a; Sindicato Nacional das Empresas Distribuidoras de Combustíveis e de Lubrificantes 2010a; Sindicato Nacional das Empresas Distribuidoras de Combustíveis e de Lubrificantes 2010b)

The market leader in both segments is Petrobras BR Distribuidora, which could increase participation from 24 to 29% (Gasolina C) and from 17 to 22% (hydrated ethanol) between 2005 and 2009. It was followed by Ipiranga with a market share of about 15% (Gasolina C) respective 13% (hydrated ethanol). But several changes occurred in the Brazilian fuel distribution market in the past years. While the Ipiranga group was bought by Petrobras, Ultra and Braskem in 2007[53], the largest ethanol and sugar group COSAN bought the assets of Exxon Mobil in Brazil in 2008 and overtook the distribution network with 1,500 fuel stations with the copyright for the brands Esso and Mobil in Brazil (Onaga 2008; Esso 2009). For the first time, a Brazilian ethanol producing company heavily invested into the strategy to commercialise ethanol fuel and fossil fuels. In 2010, COSAN signed a joint venture with the distribution company Shell and created the company Raizen for their ethanol activities in 2011 (Shell International Media Relations 2010; Alvarenga 2011). With regard to fuel stations, the number of independent fuel

[52] Sindicato Nacional de Empresas Distribuidoras de Combustíveis e Lubrificantes. It represents the distribution companies Petrobras BR, Ipiranga, Shell, BP, Repsol, ChevronTexaco, Castrol, Esso (Cosan), AleSat, Total, FIBrasil and Sabbá.

[53] The Ultra group took over the distribution network in Southern and Southeastern Brazil and Petrobras BR in Northern, Northeastern and Central-Western Brazil. The Ultra group will continue operations wih the brand "Ipiranga" while Petrobras BR can use it only until 2012. the The refinery Ipiranga in Rio Grande do Sul was acquired by Petrobras, Ultra and Braskem and is now called Refinaria de Petróleo Riograndense S.A (Neto 2007; Refinaria de Petróleo Riograndense 2009).

stations in Brazil is quite high counting 15,197 (43.3%) out of 36,730 in 2008 due to the legal situation that Brazilian distribution companies can sell their fuels only to fuel stations with their own brand or to the independent fuel stations but not to fuel stations of other distribution companies. Market leader Petrobras BR operated 6,202 fuel stations (17%) (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2009a)[54].

### 4.2.3. Consumption of ethanol in Brazil

While the fuel quality characteristics can be influenced and this is why they are specified in fuel specifications described (see chapter 3.1.7.6), the characteristics described here are general chemical-physical characteristics that can not be influenced. These characteristics of ethanol are very similar to those of gasoline and this is why it can be used as a motor fuel, either as a blend with gasoline or as neat fuel in alcohol cars or flexible-fuel vehicles. But there are also some important differences between ethanol and gasoline and spark ignition engines have to be adjusted to the use of ethanol fuel. These adjustments vary in accordance of the ethanol share of the fuel and the characteristics of the blend or neat fuel. But the Brazilian experience shows that there exist technological solutions for the challenges when introducing ethanol as an additive or neat fuel.

Table 25 – Physical-chemical properties of gasoline-ethanol blend and hydrated ethanol in Brazil (Joseph Jr. 2005)

| Characteristics | Pure Regular Gasoline | Blend E-22 (22% v/v) | Pure E-100 |
|---|---|---|---|
| Air / Fuel Stoichiometry | 14,5 : 1 | 12,7 : 1 | 9,0 : 1 |
| Specific Weight (20ºC) (kg/m³) | ± 770 | ± 780 | ± 810 |
| Heat of Combustion (kcal / kg) | ± 10.500 | ± 9.500 | ± 6.100 |
| MON | 80 ~ 83 | 80 ~ 83 | 88 ~ 90 |
| RON | 90 ~ 96 | 90 ~ 96 | 105 ~ 108 |
| (MON + RON)/2 | ≥ 87 | ≥ 87 | ≥ 95 |
| Vapour Pressure (kPa) | 55 ~ 70 | 55 ~ 70 | ≤ 40 |
| Polarity of molecule | Not polar | - | Highly polar |
| Metal Corrosivity | Reference | Higher | Higher |
| Elastomer Material Compatibility | Reference | Good (except polyamide) | Good (except polyamide) |
| Gum Formation (deposits) | Reference | Higher | None |
| Anti-oxidant & Detergent Additives | Required | Required | Not required |

An advantage of ethanol is the higher knock resistance compared to gasoline that means that ethanol does not ask for any additives[55]. Ethanol also has an oxygen content of 35%, while gasoline only con-

[54] Compared to Germany, where free fuel stations (1,660) account for only 11% of total fuel stations (14,410), this number is quite high. Market leader BP/Aral (2,407) accounts for 16% of total fuel stations in Germany in 2010 (Mineralölwirtschaftsverband 2010).

[55] Fuels with a low knock resistance tend to auto ignitions that occur before the principal combustion induced by spark-ignition. An indicator for the knock resistance of the fuel is the octane number. The research octane number (RON) of ethanol is 105-107 compared to gasoline with a RON of 90-96.

tains 0-2% of oxygen. Since oxygen promotes the combustion, blending gasoline with ethanol increases the thermal efficiency of the motor. Maximum thermal efficiency of ethanol cars is 30% compared to 27% of cars using pure gasoline (Joseph Jr. 2004)[56]. But the higher thermal efficiency of ethanol is outbalanced by its lower energy content. With a heating value of 21.17 MJ/litre, ethanol only reaches 65% of the heating value of gasoline (32.63 MJ/litre) and about 71% of the heating value of ethanol-gasoline blend (E25: 29.76 MJ/litre). All these characteristics are important variables for the additional consumption of ethanol when using it as a gasoline substitute. In engine tests, specific fuel consumption for hydrated ethanol was around 54% higher than for the gasoline-ethanol fuel blend. Thus, since better engine performance does not result in lower consumption, hydrated ethanol substitutes 72% of the gasoline-ethanol blend in engine tests (Costa and Sodré 2010). *ANFAVEA* estimates a 30% additional consumption of ethanol compared to ethanol-gasoline blends (Joseph Jr. 2004). This data shall be further used as a reference in this publication, with one litre of ethanol (hydrated as well as anhydrous) equating 0.7 litre of gasoline-fuel blend in Brazil, further referred to as fuel equivalent (FE) when compared to gasoline. A disadvantage of ethanol as a neat fuel is the lower vapour pressure which can generate problems for cold starts[57]. Since ethanol is completely soluble in water, it may increase the water content of the blend due to its water affinity. The water can also separate the ethanol from the blend and create two different phases with two very different fuel characteristics. Since this phase separation is more likely to occur at low temperatures, this does not represent a major problem in the Brazilian context with its tropical climate (Botelho 2007). Furthermore, ethanol is highly reactive because its polar hydroxyl group can be oxidised easily. This means that metal containing elements can be corroded and elastomer material (rubber seal, tubes) can swell up (Henniges 2007). The use of hydrous ethanol decreases CO and HC emissions and increases $CO_2$ and $NO_X$ emissions, when compared to gasoline-ethanol blends (Costa and Sodré 2010).

In the past, the use of more than 25% of ethanol required the development and construction of specific alcohol cars[58]. The motor was developed by the Brazilian Air Force in the 1970s and manufactured by the Brazilian automotive industry since the second phase of *PROÁLCOOL* until recently (Paixão 1996; Borges et al. 1984). Since the price relation between neat ethanol and gasohol was controlled by the government in the 1980s to encourage ethanol consumption through attractive retail prices, ca. 90% of all passenger cars sold in Brazil between 1983 and 1988 were alcohol cars. But when ethanol supply could not satisfy the growing demand for ethanol in 1989 and Brazil had to import some ethanol, consumers lost their confidence in the supply security and sales of alcohol cars decreased dramatically. Therefore, Brazilian engineers developed various prototypes of so called flexible-fuel vehicles (FFV) in the 1990s that were introduced into the market in 2003 when high oil prices renewed the interest in ethanol as a neat fuel. Registration of FFV rose sharply, reaching 86% on overall light vehicles (passenger cars and light commercial vehicles) in 2010 (Associação Nacional dos Fabricantes de Veículos Automotores 2010a; Associação Nacional dos Fabricantes de Veículos Automotores 2011a) (see figure

[56] Comparing ethanol fuel with the ethanol-gasoline blend (E22), thermal efficiency of hydrated ethanol improves up to 14% (Costa and Sodré 2010).
[57] Blending gasoline with ethanol does not reduce the vapour pressure but increases it instead. This phenomenon is known as vapour pressure anomaly and provokes bubbles that may affect motor performance negatively. A high vapour pressure can also result from a higher water content of the ethanol-gasoline-blend.
[58] Due to the different characteristics of gasoline, ethanol and its blends, gasoline cars have to be submitted to certain adjustments when using ethanol. Up to an ethanol content of 5% no modifications have to be realised. With 5-10% ethanol content the carburettor has to be adjusted. Blending the gasoline with 10-25% of ethanol, the electronic fuel injection, the fuel pressure device, the fuel pump, the fuel filter, the ignition system, the evaporative system, the fuel tank and the catalytic converter have to be adjusted as well. Since there is not offered any neat gasoline fuel at petrol stations in Brazil, but only an ethanol-gasoline-blend called “gasohol” with 20- 25% of ethanol, every passenger car in Brazil has to be submitted to these adjustments. For blends with an ethanol content of 25-85%, the basic engine, the motor oil, the intake manifold and the exhaust system have to be adjusted in addition to the other adjustments. When using more than 85% of ethanol a cold start system has to be installed in the car to avoid problems (Joseph Jr. 2005).

14). These FFV run with any blend of gasoline and ethanol, more specifically for Brazil, with any blend of gasoline, anhydrous and hydrated ethanol[59]. In fact, flexible-fuel vehicles in Brazil are optimised for the use of high ethanol blends. The lower density and better knock resistance of ethanol allow a higher compression rate that reduces fuel consumption. Whereas the first FFV models launched in 2003 had compression rates similar to gasoline cars and therefore high fuel consumption when using ethanol (9:1), the current models have compression rates between 11:1 and 13:1 that are closer to compression rates of neat ethanol cars[60] (Joseph Jr. 2007). Since most of the car models of the Brazilian manufacturers are offered only in the flexible-fuel version, flexible-fuel vehicles have become the standard passenger car type in Brazil in the past years. Until December 2010, already 12.5 million FFV had been licensed in Brazil since its introduction in 2003 (Associação Nacional dos Fabricantes de Veículos Automotores 2011b). Assuming that all these FFV were still registered, FFV would represent 34% of total Brazilian passenger vehicle fleet of 37.2 million at December 2010 (Departamento Nacional de Trânsito 2010).

The commercial success of the flexible-fuel vehicles is not limited to just substituting the gasohol passenger cars in Brazil. With the growing participation of FFV, overall sales of passenger cars increased in general before the crisis in 2008. Although reasons for increasing sales of passenger cars may be diverse and include general economic growth and more equal income distribution, the introduction of FFV into the Brazilian market also contributed to increasing light vehicles' sales. Motorisation of the Brazilian society grew from 118 vehicles per 1,000 inhabitants at December 2000 (169.8 million inhabitants, 20 million light vehicles) to 195 vehicles per 1,000 inhabitants at December 2010 (190.7 million inhabitants, 37.2 million light vehicles) (Departamento Nacional de Trânsito 2010; Instituto Brasileiro de Geografia e Estatística 2010b). Although this is much lower than the vehicles ratio of countries like Germany (508 vehicles/1,000 inhabitants[61], increasing vehicles sales follow mobility patterns typical for industrialised countries (Kraftfahrzeugbundesamt 2010). The growing Brazilian light vehicle fleet resulted in higher fuel sales, except during the 2008 economic crisis. While Gasolina C sales increased from 23.5 billion litres in 2005 to 29.8 billion litres in 2010 (27% increase), ethanol sales increased from 3.3 billion litres FE in 2005 to 10.6 billion litres FE in 2010 (221% increase) (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2011a). Except during the economic crisis in 2008/09, total light vehicle registration grew in the past years in Brazil and so did fuel consumption and especially ethanol fuel consumption (see figure 15 and table 50 in the annex).

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[59] The fuel mixture is recognised by a lambda sensor that measures the oxygen content of the exhaust gas. This information is sent to a specific electronic device whose software compares this data with its data set and induces changes of the parameters that regulate the air-fuel combustion ratio when necessary. A high oxygen content of the exhaust gas indicates high ethanol content of the fuel inducing a leaner air-fuel mixture due to the higher laminar flame speed of the ethanol. The combustion is most efficient, when there remains no excess air or fuel after the combustion process. Therefore, the right mixture of fuel and air, that is called stoichiometric fuel-air ratio, is very important, but varies in accordance to the fuel. The stoichiometric air-fuel ratio for 100% gasoline is 14.5:1, for E22 12.7:1 and for E100 9:1 on a weight basis (Joseph Jr. 2005). Besides, low-torque and high-torque loads ask for rich respectively lean fuel-air mixtures. There is also a special fuel pump that detects recent refueling that could signify a change in the fuel composition, also special injectors are used in FFV. Beside these specific developments, the same adjustments concerning the material of the components described earlier for high ethanol contents have to be realised.

[60] In general, FFV technology in Brazil differs in some important characteristics from the technology used in the United States, for instance. Initially, FFV in the US were developed for using gasoline and methanol and therefore asked for a different technology using optical sensors analysing the stoichiometric air-fuel-ratio of the fuel mixture before the combustion process in addition to the lambda sensor that measures the exhaust gas (Damasceno and Montanari 2004). Flexible-fuel vehicles have also been introduced in several countries of the EU in the last years. Ford, Saab and Volvo offer various models that follow the US experience since E85 is being offered at selected fuelling stations in the EU. However, these recent developments can not be compared with the Brazilian situation and will be restricted locally and quantitatively due to the limited production volumes of ethanol considering the total fuel consumption in the US, the EU and other countries (Joseph Jr. 2007).

[61] With a population of 82 million and 41.7 million registered passenger cars, including 10 million passenger cars with a compression ignition engine.

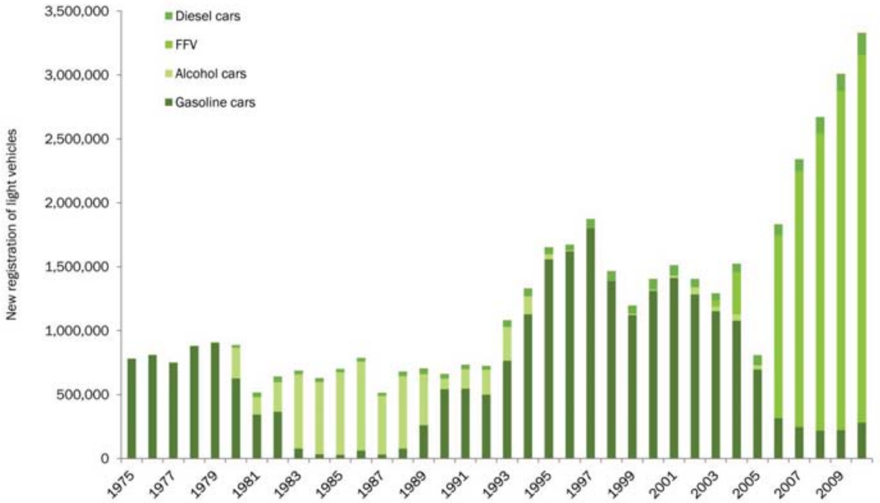


Figure 14 – New registration of light vehicles in Brazil 1975-2010 (Giersdorf, based on (ANFAVEA 2010a; ANFAVEA 2011b))

However, the sharp increase of ethanol fuel consumption in 2008 may be partly due to increasing control activities of the fuel market and a shift from illegal sales to legal sales of ethanol fuel. The hypothesis that some part of the hydrated ethanol fuel consumption only appeared in official *ANP* statistics after increasing control activities can be validated when comparing ethanol production (supply) and ethanol consumption and exports (demand) between 2005 and 2007. Since ethanol fuel supply exceeded demand considerably in all these years[62] and since neither the ethanol plants nor the distribution companies build stocks for ethanol supply for more than one harvest, this difference can only be explained by considerable volumes of illegal sales of ethanol fuel until 2007. Assuming that between 2005 and 2007 annual sales of about 1.1 billion litres of hydrated ethanol FE shifted from illegal to declared ethanol sales, real monthly sales of hydrated ethanol would have been 90 respectively 60 million litres of FE higher than the statistical values of 270 (2005) and 390 (2006) million litres of FE for these years. This would reduce the statistical increase of ethanol sales, but even the supposed increase from medium monthly sales of 360 (2005) and 450 (2006) million litres of FE to 520 million litres of FE in 2007 is very significant. It is thus a fact that the increase in FFV sales contributed to an increase in gasoline and ethanol fuel sales. This is important when considering the discussion about ethanol substituting gasohol or gasoline as a fuel and therefore enhancing national energy independence and reducing global warming. The facts analysed in this chapter suggest that ethanol and FFV not only substitute gasoline but also serve to enhance energy supply and energy consumption in general. This would be quite a different situation than during *PROÁLCOOL* (1975-1990), when hydrated ethanol effectively substituted gasoline and caused a considerable decrease in gasoline sales (Queiroz Pinto Jr. 2002).

[62] Total ethanol supply amounted to 10.9 (2005), 11.6 (2006) and 13.4 billion liters GE (2007), total ethanol consumption to 7.4 (2005), 7.9 (2006) and 10.4 billion liters GE (2007) and total ethanol exports to 1.8 (2005), 2.4 (2006) and 2.5 billion liters (2007). This resulted in oversupply of ethanol of 1.7 (2005),1.3 (2006) and 0.6 billion litres gasoline-equivalent (2006).

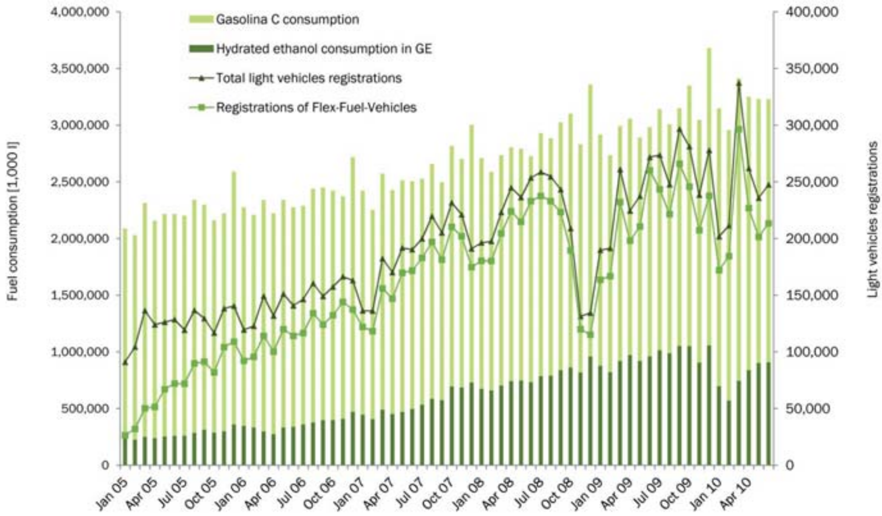


Figure 15 – Monthly registrations of light vehicles and monthly sales of gasoline and ethanol fuel in Brazil, 01/2005-12/2010 (Giersdorf, based on (Associação Nacional dos Fabricantes de Veículos Automotores 2009a; Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2011a))

### 4.2.4. Development of Brazilian ethanol exports

Until 2003, Brazilian ethanol exports were quite low, but with the dynamisation of the Brazilian sugar and ethanol market in 2002/03 (see chapter 3.1.7) and increasing international interest in biofuels, ethanol exports increased from 734 million litres in 2003 to 2.3 billion litres in 2004. Either directly or via the countries of the *Caribbean Basin Initiative* (*CBI*)[63] and the *Dominican Republic-Central America Free Trade Agreement (CAFTA-DR)*[64], in which Brazilian hydrated ethanol is being dehydrated in several dehydration facilities in order to avoid the 0.54 USD/litre import tariff on ethanol, the United States have been the most important export market for Brazilian ethanol in the past years with a peak of 1.75 billion litres of imports in 2008 (Giersdorf 2010; Bevill 2009). The countries of the European Union are also an important market for Brazil with imports between 500 million litres and 1.4 billion litres annually between 2005 and 2009, mostly via the port of Rotterdam. South Korea and Japan are other important markets, even though Japanese imports did not fulfil Brazilian expectations of increasing demand which had led to various joint ventures to satisfy the expected growing trade flows (CPA 2009). Total Brazilian ethanol fuel exports declined in 2009 (3.3 billion litres) and 2010 (1.6 billion litres) after a peak in 2008 with 5.1 billion litres (União da Indústria de Cana-de-Açúcar 2010a). In 2012, ethanol exports increased to 2.6 billion litres due to the sharp increase of US imports (1.8 billion litres) (União da Indústria de Cana-de-Açúcar 2012).

[63] Launched in 1983, and substantially expanded in 2000, the CBI currently provides beneficiary countries with duty-free access to the U.S. market for most goods. There are currently 17 beneficiary countries: Antigua and Barbuda, Aruba, The Bahamas, Barbados, Belize, British Virgin Islands, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, Panama, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Trinidad and Tobago (Office of the United States Trade Representative 2012a).

[64] In 2004, the United States of America signed the Dominican Republic-Central America-United States Free Trade Agreement (CAFTA-DR) with five Central American countries (Costa Rica, El Salvador, Guatemala, Honduras, and Nicaragua) and the Dominican Republic (Office of the United States Trade Representative 2012b).

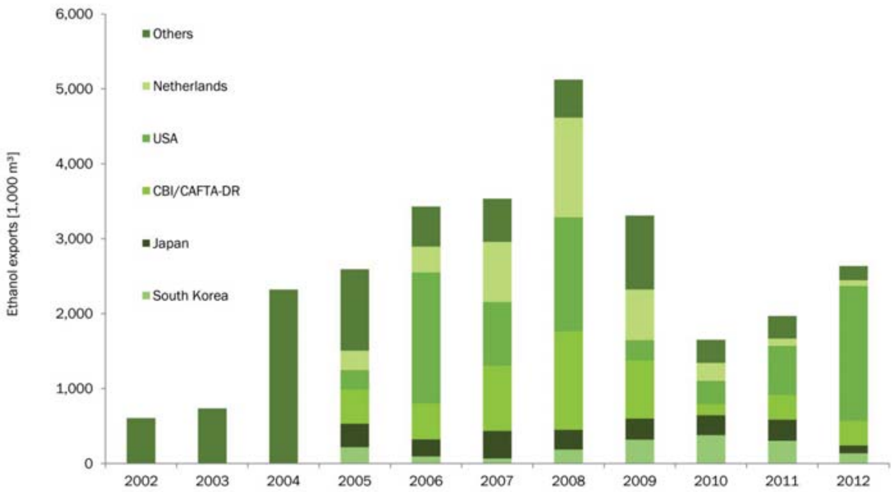


Figure 16 – Brazilian ethanol exports by destination country 2002-2012 (Giersdorf, based on (União da Indústria de Cana-de-Açúcar 2010a; União da Indústria de Cana-de-Açúcar 2012))

Since in January 2012, the *US Congress* refused to extend the 54-cents-per-gallon tariff levied against imported ethanol, the US market suddenly was open to Brazilian ethanol imports (Mathews 2012). But there is also a need for increasing imports of Brazilian ethanol: In 2007, a quote for advanced biofuels was established by the Renewable Fuel Standard (RFS) for the US market. For 2012, 1.9 billion litres of the total biofuel blending target of 57.5 billion litres could come from unspecified advanced biofuels[65] (Schnepf and Yacobucci 2012). Since the *United States Environmental Protection Agency (EPA)* defines advanced biofuels as anything except corn starch ethanol – especially, but not necessarily, cellulosic biofuels and biomass-based diesel – that must meet a 50% lifecycle GHG emission mitigation threshold, Brazilian ethanol already had been classified as an advanced biofuel in 2010 by this agency (Ministério das Relações Exteriores 2010). Thus, the Brazilian exports completely satisfied the demand for unspecified advanced biofuels in 2012, and with an annual increase of about 950 million litres of this quota, the market opportunities of Brazilian ethanol exports to the US remain very good. But the volume of Brazilian ethanol exports oscillated heavily in the past years because of the limited international trading volume of ethanol with Brazil as the only significant ethanol exporter. Changes in US and EU import tariffs, increasing blending targets in the US and discussions about the reduction of the blending target in the EU heavily influence market opportunities for Brazilian ethanol exports. The oscillating demand for Brazilian sugar exports also influences the economics of sugar and ethanol production and exports in Brazil (see chapter 4.2.5). Thus, it is very difficult to predict development of Brazilian ethanol exports for the future: With a participation of about 10% or more on Brazilian ethanol production, exports probably will continue to be important, but domestic market developments will remain the most important driving force for Brazilian ethanol production.

[65] Cellulosic biofuel and biodiesel are the specified advanced biofuels that have a minimum quota.

### 4.2.5. Economics of Brazilian ethanol production

Until 1997 prices for sugarcane, sugar and ethanol were determined by the government based on production costs collected and published by the Foundation Getúlio Vargas (Almeida, José Vitor Bomtempo and Carla Maria Souza e Silva 2007). Since then, few systematic assessments for production costs have been made. Since sugarcane accounts for roughly 60% of total ethanol production costs, to estimate the costs for sugarcane is crucial. Most studies like (Macedo 2005) rely on the prices paid to the sugarcane growers in the state of São Paulo according to the system *CONSECANA*. Since these prices are based on national and international sugar and ethanol prices, they rather express opportunity costs than agricultural production costs and (marginal) profits of the growers. But when the sugarcane is acquired by the ethanol plants, they represent feedstock costs for these plants. The sugarcane prices increased and decreased according to international sugar (and ethanol prices) in the past and thus reflect national and international price movements of the final products (see table 26).

Table 26 – Sugarcane prices and participation on ethanol production costs in Brazil (Giersdorf, based on (Conselho dos Produtores de Cana, Açúcar e Álcool do Estado de São Paulo 2010; União dos Produtores de Bioenergia 2011))

| Harvest season | Sugarcane prices in BRL/ton | Sucrose content in kg TRS/ton | Sucrose price in BRL/kg TRS | Sugarcane costs in BRL/litre hydrated ethanol[66] | Sugarcane costs in BRL/litre anhydrous ethanol[67] |
|---|---|---|---|---|---|
| 2000/01 | 29.85 | 142.15 | 0.20 | 0.34 | 0.36 |
| 2001/02 | 29.96 | 144.47 | 0.21 | 0.36 | 0.38 |
| 2002/03 | 35.99 | 147.62 | 0.24 | 0.42 | 0.44 |
| 2003/04 | 30.22 | 148.88 | 0.20 | 0.35 | 0.37 |
| 2004/05 | 35.06 | 143.70 | 0.24 | 0.42 | 0.44 |
| 2005/06 | 44.99 | 145.96 | 0.31 | 0.54 | 0.56 |
| 2006/07 | 51.74 | 150.86 | 0.34 | 0.60 | 0.62 |
| 2007/08 | 35.89 | 146.57 | 0.24 | 0.43 | 0.44 |

Prices for sugarcane varied between 30 and 50 BRL/ton sugarcane (15-25 USD/ton sugarcane) in the past years. During the 2008/09 harvest, growers in São Paulo received about 32 BRL/ton sugarcane (16 USD/ton), only slightly above production costs calculated with about 14-16 USD/ton sugarcane for 2005[68] (Van den Wall Bake et al. 2009). However, sugarcane production costs vary considerably throughout Brazil and depend on the property size, technology, climate, soil and other factors. Data indicate that even for many regions in the Southeast, sugarcane production costs may exceed 40 BRL/ton sugarcane (20 USD/ton), and thus be in fact higher than costs of 10 USD/ton sugarcane which are used in most studies on Brazilian ethanol (Assocana 2009)[69]. For the total ethanol production costs, Kojima and Johnson (2005) calculated production costs of 0.22-0.29 USD/litre ethanol, while

[66] With 1.7409 kg TRS per litre hydrated ethanol (Conselho dos Produtores de Cana, Açúcar e Álcool do Estado de São Paulo 2005)

[67] With 1.8169 kg TRS per litre anhydrous ethanol (Conselho dos Produtores de Cana, Açúcar e Álcool do Estado de São Paulo 2005)

[68] Cost factors such as land rent, soil preparation, stock maintenance, harvest and transport contributed quite equally to total sugarcane production costs according to this study.

[69] In the Northeast, sugarcane production costs were above 66 BRL/ton in 2008, while prices paid were below 40 BRL/ton, thus leading to continuous claims of the producers asking the government to intervene and pay minimum prices (Companhia Nacional de Abastecimento 2009b).

van den Wall Bake et al. (2009) estimated much higher production costs with 0.31-0.37 USD/litre ethanol. But this is in line with Almeida, José Vitor Bomtempo and Carla Maria Souza e Silva (2007) that estimated ethanol production costs of new ethanol projects to amount to 0.37 USD/litre ethanol. The higher costs result from two important factors which are often not considered in standard estimates: the capital opportunity cost instead of the capital depreciation and the sugarcane opportunity costs, since ethanol mills acquire at least one third of their sugarcane supply from farmers.

Table 27 – Estimated ethanol production costs in Brazil, the US and the EU [USD/litre]

| Sugarcane ethanol, Brazil | | Corn Ethanol, USA | | Wheat ethanol, EU | |
|---|---|---|---|---|---|
| Kojima und Johnson 2005 | van den Wall Bake u. a. 2009 | Hettinga et al. 2009 | USDA 2011 | USDA 2006 | Klenk and Kunz 2008 |
| 0.22-0.29 | 0.31-0.37 | 0.31-0.33 | 0.40-0.55 | 0.70-0.80 | 0.70-0.80 |

Brazilian ethanol production costs are relatively lower than ethanol production costs in the United States and the European Union, but data should be analysed carefully since production costs are often only estimates based on market prices and highly sensitive to changes in exchange rates. Estimates for US corn ethanol production costs range between 0.31-0.33 USD/litre (Hettinga et al. 2009) and 0.40-0.55 USD/litre (United States Department of Agriculture 2011c) and for wheat ethanol in the EU from 0.48-0.55 USD/litre (United States Department of Agriculture 2006) to 0.70-0.80 USD/litre (Klenk and Kunz 2008).

Due to the relatively low production costs, consumer prices can be expected to be competitive compared to gasoline prices, especially considering the tax advantages for ethanol consumption (see chapter 3.1.7.3). However, between 2006 and 2010 ethanol fuel was competitive in states like São Paulo and Bahia, but not in Pará, considering that ethanol prices should not exceed 70% of gasoline prices due to additional consumption, (see figure 17). In the state of São Paulo prices of hydrated ethanol oscillated between 50% and 60% of gasoline prices at fuel stations during the period considered, except of the beginning of 2010. In the state of Bahia, ethanol prices were almost 70% of gasoline prices in the past years and thus also competitive. But in the state of Pará where almost no ethanol is produced, ethanol prices reached between 75% and 95% of gasoline prices and thus gasoline and not ethanol was more advantageous for consumers in the past years. While prices for Gasolina C were quite similar in the different states oscillating between 2.40 and 2.80 BRL/litre, prices for hydrated ethanol varied considerably between São Paulo, where they rarely exceeded 1.40 BRL/litre, and the state of Pará, where they almost never fell below 2.00 BRL/litre (see table 51 in the annex).

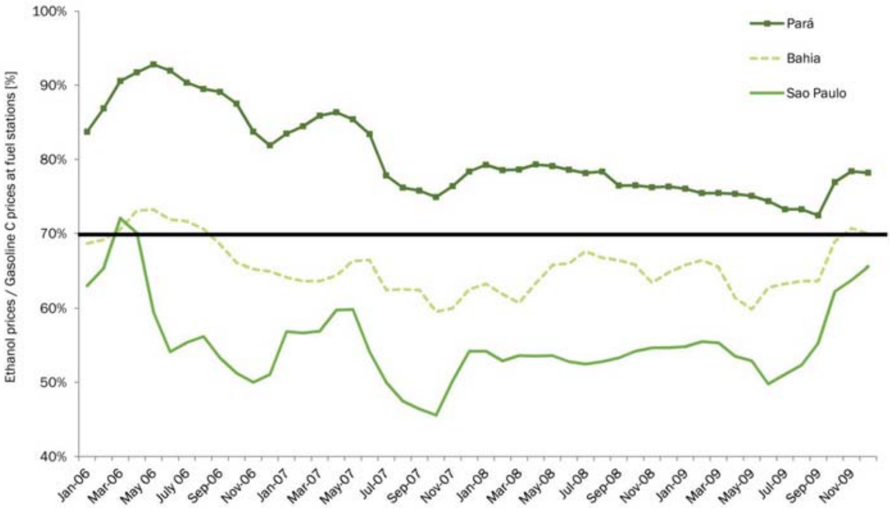


Figure 17 – Price relations between hydrated ethanol and Gasolina C at fuel stations in Bahia, Pará and São Paulo 01/2006-12/2010 (Giersdorf, based on (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2010a))

Thus, the price relations are a result of varying ethanol prices between the states, and competitiveness of ethanol is given in most ethanol producing states but rarely in ethanol importing states. Although competitiveness of ethanol vs. gasoline is an important factor for economic viability of ethanol production, sugar prices play a crucial role as well. As Brazil is the most important sugar producer and exporter worldwide, sugar prices can be computed as the opportunity costs of ethanol production (Kojima, Mitchell and Ward 2007). Based on the relation of sugar and transport fuel prices (gasoline, ethanol), the sugar and ethanol plants change the output relation of sugar and ethanol production (see chapter 4.2.1.3). It should be considered, however, that Brazil sells significant amounts of sugar at the spot market and sugar exports even exceed domestic consumption but for ethanol production the export share does not exceed 10%.

Computing world market sugar prices as opportunity costs for the ethanol production thus only partly represents reality (see figure 18). The line of indifference represents any price relation between sugar and ethanol on a given day, for which ethanol production would be as feasible as sugar production. The area on the left demarks price relations favourable to the production of ethanol, the area on the right price relations favourable to the production of sugar. In the case of gasoline prices below 48 USD/bbl and sugar prices below 0.07 USD/lb, neither ethanol nor sugar production is feasible, but the production of alternative agricultural products. In most of the cases, sugar production would have been more feasible than ethanol production. Only during the period of soaring crude oil and gasoline prices in 2007/08, the production of ethanol was more attractive. But when international fossil fuel prices declined sharply in 2009, this situation reversed again. Although international gasoline spot prices increased to 100 USD/bbl again in 2010/11, high international sugar spot prices of more than 30 USD/bbl explain the shift in Brazilian production to sugar (see also table 52 in the annex).

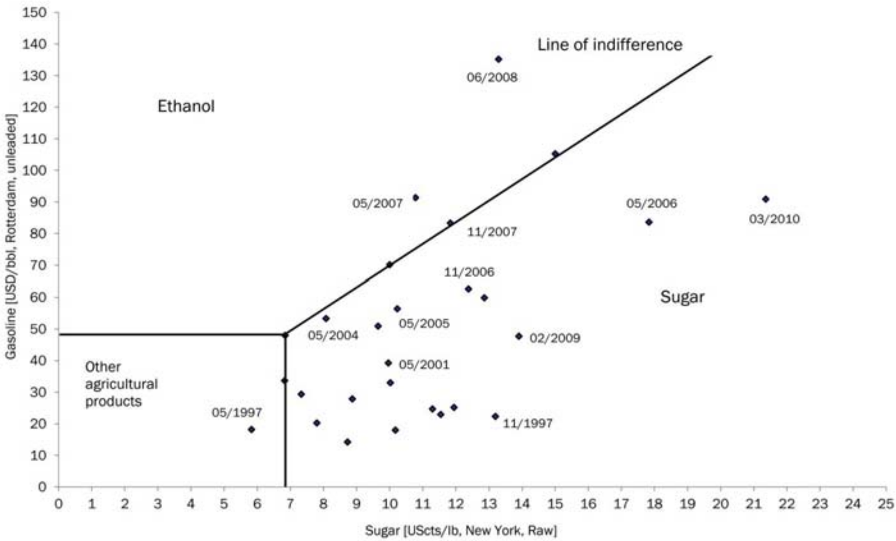


Figure 18 – World market ratio for ethanol[70] and sugar[71] production in Brazil 1997-2010 (selected price combinations) (Giersdorf, based on (Borges et al. 1988), Data (International Energy Agency 2008; United States Energy Information Administration 2010a; United States Department of Agriculture 2012b))

## 4.2.6. Critical analysis of selected ethanol support policies

Since the support policies for ethanol are often justified with the positive economic, social and environmental effects of ethanol production and use, these effects would have to be analysed in detail. Since there exist already several studies assessing especially the social and environmental effects of ethanol in Brazil, only selected economic impacts of the support policies shall be analysed here briefly.

### 4.2.6.1. Public financing and the problem of debt renegotiations

As already described in chapter 3.1.7.1, the national development bank *BNDES* is financing ethanol and sugar investments through specific credit lines which represent an important source for funding of the sector (Antonio de Pádua Rodrigues 2007). In 2009, *BNDES* portfolio for the sector summed up to 25.5 billion BRL (incl. investments and financing) and included more than 50% of all investments in this sector in Brazil (Torres Filho and Pimentel Puga 2007). Since there are frequent announcements about private and especially foreign direct investments in the Brazilian ethanol industry, the strong public financing is surprising. It is difficult to evaluate whether ethanol producers are heavily relying on public financing because of high interest rates at the Brazilian capital market or because investments risks are still high due to cyclical development of the sugar and gasoline/ethanol prices and oscillating harvest yields (Castro de Rezende and Kreter 2007). According to Castro de Rezende (2007), private fi-

[70] Prices for Amsterdam-Rotterdam-Antwerp (ARA) 10ppm Conventional Gasoline Regular Spot Price FOB in the United States (United States Energy Information Administration 2010a).
[71] Prices for Sugar Contract No. 11-f.o.b. stowed Caribbean port, including Brazil, bulk spot price, plus freight to Far East (United States Department of Agriculture 2012b).

nancing for the agro-industrial complex is scarce because of a high risk, since debts have been renegotiated frequently in the past due to the economic and political power of the agro-industrial complex. And due to the fact that the growth of national ethanol production is part of the *Programa de Aceleração do Crescimento* (*PAC* - Programme for Growth Acceleration), the ethanol and sugar producers can count with favourable conditions. For *BNDES* itself, loan losses do not represent a major problem, since most of the resources granted to the agricultural sector originate from public federal and regional funds that are provided constantly with capital by social contributions[72] (Castro de Rezende 2007). The effects of the *BNDES* financing of modernisation and mechanisation investments on the rural development are twofold: These programmes help to develop a national equipment industry, but at the same time they reduce the demand for labour in rural regions which already have to fight high unemployment rates (Castro de Rezende 2005). In order to prevent negative impacts of the financing activities of the *BNDES*, social NGOs claim for the inclusion of stricter social criteria for financing lines by the bank (Plataforma BNDES 2008).

## 4.2.6.2. Tax losses due to tax advantages of hydrated ethanol

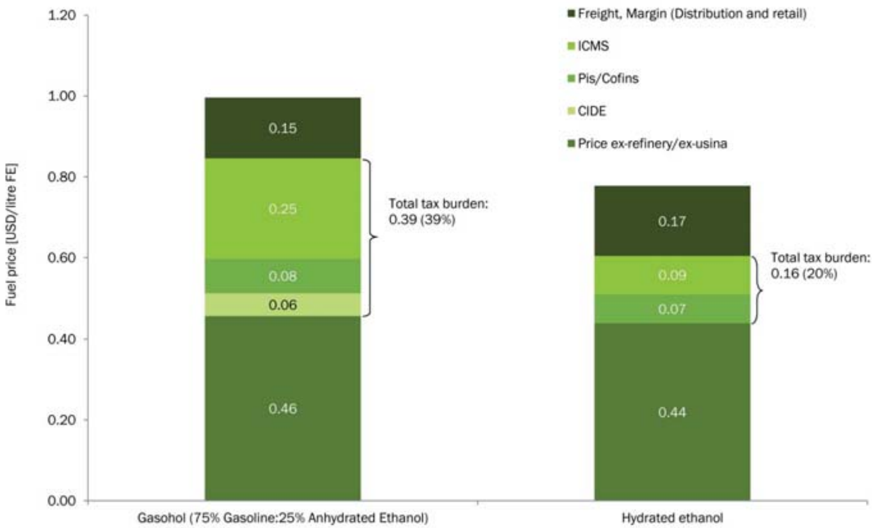


Figure 19 – Composition of hydrated ethanol and Gasolina C prices in São Paulo state 12/2008 [USD/litre FE] (Giersdorf, based on (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2010a; Centro de Estudos Avançados em Economia Aplicada 2009))

As already described in chapter 3.1.7.3, there are federal *and* state taxes on transport fuels, and this is why it is difficult to compare the tax burden of hydrated ethanol with gasohol for Brazil as a whole.

[72] One of the most important sources for *BNDES* financing lines is the worker's assistance fund (*FAT - Fundo de Amparo ao Trabalhador*), which is provided with capital by the social contribution *PIS*, of which 40% of the revenue has to serve for *BNDES* to finance economic development projects (Machado dos Santos 2006). The *FAT* has a deliberative council composed by four representatives of the workers, four representatives of the employers and four government representatives. This council develops the directives for financing programmes considering the general economic development directives and decides upon a considerable resource allocation, in June 2006 the balance of this fund was about 90 billion BRL.

Therefore, the following observations are based on calculations for São Paulo state, which accounted for 57% of ethanol (16.5 billion litres) and 29% of gasohol (21.2 billion litres) consumption in Brazil between 2006 and 2008. In December 2008, consumer prices for Gasolina C amounted to 2.40 BRL/litre (1.00 USD/litre), while prices ex-refinery/ex-usina amounted to 1.10 BRL/litre (0.46 USD/litre). Subtracting freight and margins (0.36 BRL/litre or 0.15 USD/litre), federal and state taxes amounted to 0.93 BRL/litre (0.39 USD/litre) and had a share on end consumer prices of about 39% in São Paulo state. Consumer prices for hydrated ethanol amounted to 1.87 BRL/litre GE (0.78 USD/litre FE), while prices ex-usina amounted to 1.06 BRL/litre GE (0.44 USD/litre FE). Subtracting freight and margins (0.41 BRL/litre FE or 0.17 USD/litre FE), federal and state taxes amounted to 0.39 BRL/litre FE (0.16 USD/litre FE) and had a tax share of only 20% of end consumer prices in São Paulo state (see figure 19).

Comparing the tax burden of gasohol with that of hydrated ethanol on a gasoline-equivalent basis, hydrated ethanol had a tax advantage of 0.53 BRL/litre FE (0.23 USD/litre FE). This tax advantage is quite considerable but the result is in line with a study of the World Bank realised in 2005 that calculated a tax advantage of 0.30 USD/litre for Brazilian ethanol, which equals 0.21 USD/litre FE (Kojima and Johnson 2005).

In 2006, consumption of hydrated ethanol in the state of São Paulo amounted to 3.74 billion litres, thus substituting 2.62 billion litres of Gasolina C, in 2007 consumption increased to 5.53 billion litres (3.87 billion litres FE) and in 2008 to 7.25 billion litres (5.08 billion litres FE), surpassing Gasolina C consumption for the first time in the history of the state of São Paulo (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2010b). Thus, federal and state treasury renounced on tax revenues of 1.66 billion BRL (0.76 billion USD) in 2006, of 2.53 billion BRL (1.31 billion USD) in 2007 and 2.96 billion BRL (1.65 billion USD) in 2008, if ethanol would have been taxed like gasohol. Comparing this tax renounces with total federal and state tax revenues for Gasolina C and hydrated ethanol in São Paulo state, the increasing ethanol consumption shows effect. In 2006, total revenues summed up to 8.36 billion BRL (3.84 billion USD), in 2007 to 8.69 billion BRL (4.47 billion USD) and in 2008 to 8.63 billion BRL (4.78 billion USD). Thus, due to the lower tax burden on hydrated ethanol, federal and state treasury renounced on 16% (2006), 23% (2007) and 26% (2008) of total theoretical tax revenues on fuels for passenger cars in São Paulo state (see table 28 and figure 20).

Table 28 – Ethanol and Gasolina C consumption and tax revenues in São Paulo state 2006-2008 (Giersdorf, based on (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2010a; Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2010b; Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2010c; Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2011a))

| | | | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|
| A | Gasolina C consumption | bn litre FE | 7.04 | 7.15 | 7.02 |
| B | Hydrated ethanol consumption | bn litre | 3.74 | 5.54 | 7.25 |
| C = B * 0.7 | Hydrated ethanol | bn litre FE | 2.62 | 3.88 | 5.08 |
| **D = A + C** | **Total fuel consumption** | **bn litre FE** | **9.66** | **11.03** | **12.10** |
| E = A * tax burden Gasolina C | Tax revenue Gasolina C | bn USD | 3.36 | 3.74 | 3.74 |
| F = B * tax burden hydrated ethanol | Tax revenue ethanol | bn USD | 0.48 | 0.73 | 1.04 |

| | | | | | |
|---|---|---|---|---|---|
| **G = E + F** | **Total tax revenue** | **bn USD** | **3.84** | **4.47** | **4.78** |
| H = E + C * tax burden Gasolina C | Theoretical tax revenue if ethanol = gasoline treatment | bn USD | 4.61 | 5.78 | 6.43 |
| **I = H – G** | **Tax losses** | **bn USD** | **0.76** | **1.31** | **1.65** |
| **J = I / G** | **Share of losses on total theoretical revenues** | **%** | **16** | **23** | **26** |

Since tax advantages for hydrated ethanol are much lower in most other Brazilian states because of higher *ICMS* rates on hydrated ethanol, tax losses in these states will be lower as well. But considering that São Paulo accounted for 54-60% of hydrated ethanol fuel consumption in Brazil between 2006 and 2008 and that total tax revenues in Brazil on fuels (including gas oil, kerosene, natural gas, etc.) amounted to 50 billion BRL in 2006, tax losses of 0.76 USD for the state of São Paulo are significant in the Brazilian context (Schupp 2007). Tax losses would have been even higher, if the government would not have reduced *CIDE* rate on Gasoline A from 280.00 BRL/m³ to 180.00 BRL/m³ in May 2008. However, the reduction of *CIDE* intended to reduce the impact of the adjustment of the domestic gasoline price to increasing international oil and gasoline prices and thus not to worsen competitiveness to ethanol. Thus, ethanol prices have a direct effect on gasoline prices and taxation and since ethanol has a tax advantage, this enhances pressure on gasoline prices and taxation.

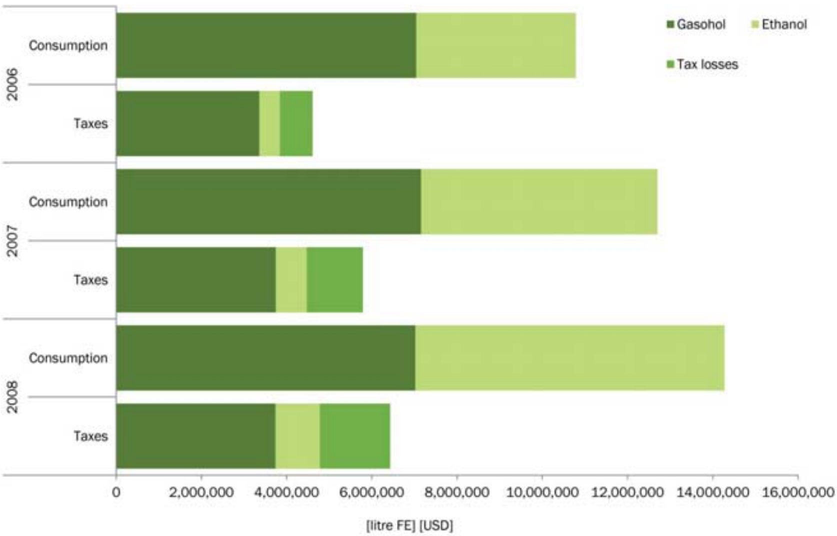


Figure 20 – Gasoline and ethanol consumption and tax revenues in São Paulo state 2006-2008 (Giersdorf, based on (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2010a; Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2010b; Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2010c; Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2011a))

Taxes on ethanol could be increased, but critics allege that trade-offs could occur, when trying to increase taxes. Elevation of tax burden on hydrated ethanol could lead to an increase in tax evasion in the state of São Paulo. The problem of tax evasion due to fictitious inter-state transactions of hydrated ethanol benefiting illegally from lower *ICMS* rates for these sales was one of the reasons for reducing *ICMS* rate for hydrated ethanol from 25% to 12% at the end of 2003. Indeed, sales of hydrated ethanol accounted in official statistics by the *ANP* increased from 1.43 billion litres in 2003 to 2.33 billion litres in 2004 confirming a shift from illegal sales to legal sales thus elevating also revenues from *ICMS* for hydrated ethanol (Capela 2004). However, these problems are caused by *ICMS* legislation (see chapter 3.1.7.3) and could be addressed by a harmonisation of *ICMS* rates for ethanol through an agreement at the *CONFAZ* for instance. Stronger enforcement of the monitoring activities by the state and federal agencies represent another alternative to limit tax evasion without necessarily a lower tax burden on hydrated ethanol compared to *Gasolina C*.

### 4.2.6.3. Tax losses due to tax reductions on FFV

In the past decade, lasting or temporary reductions of the *Imposto de Produtos Industrializados (IPI)* for different engine displacement segments and different fuel types of passenger cars have been adopted by the federal government. FFV have been introduced very successfully into the Brazilian market representing the vast majority of sales of passenger cars. This raises the question about the justification of the privileged tax treatment of FFV (see chapter 3.1.7.4).

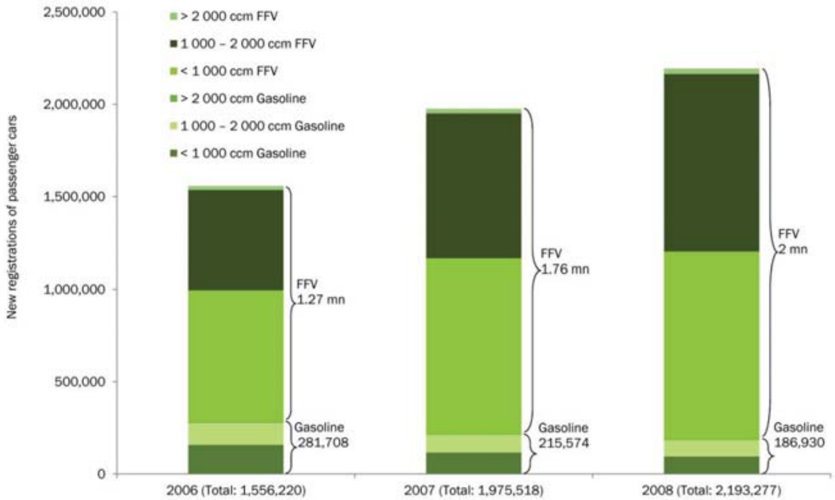


Figure 21 – New vehicle registration by engine displacement and fuel type 2006-2008 (Giersdorf, based on (Associação Nacional dos Fabricantes de Veículos Automotores 2009a))

As described in chapter 4.2.3, consumption of hydrated ethanol also increased due to increasing registration of FFV in the past years. But since this measure only indirectly promotes ethanol consumption, the tax losses resulting from the tax benefits for ethanol cars shall be analysed in this chapter. In 2006, 1.55 million new passenger cars were licensed in Brazil. This number increased to 1.98 million in 2007 and 2.19 million in 2008. Two important tendencies can be observed when analysing this increase:

1. While every engine displacement segment increased in absolute terms, passenger cars with an engine displacement of 1,000 to 2,000 ccm increased participation from 42% to 45% and passenger cars with up to 1,000 ccm decreased between 2006 (56%) and 2008 (51%). The share of passenger cars with more than 2,000 ccm was negligible with about 1.5% in this period.
2. Participation of FFV and alcohol cars[73] on registration of new passenger cars rose from 82% (2006) to 92% (2008). Especially the increase in annual sales of FFV with an engine displacement of 1,000 to 2,000 ccm from 540,000 (2006) to 962,000 (2008) is very remarkable (see figure 21 and table 53 in the annex).

Based on the tax reduction described in chapter 3.1.7.4 and considering sale prices of 30,000 BRL for passenger cars with 1,000 ccm to 2,000 ccm and 60,000 BRL for passenger cars with more than 2,000 ccm, the tax advantages for the FFV models between 2006 and 2008 can be calculated (Emiliani and Figueiredo 2005; Morelli 2005). Thus, a FFV model with 1,000 to 2,000 ccm had a minimum tax advantage of 478 BRL and a FFV model with more than 2,000 ccm a minimum tax advantage of 2,847 BRL compared with the gasoline model (see table 29).

Table 29 – Tax advantages for FFV compared to gasoline cars in Brazil (Giersdorf, based on (Emiliani and Figueiredo 2005; Morelli 2005; Presidência da República 2004c; Presidência da República 2006c; Presidência da República 2008e; Presidência da República 2009b))

| Engine displacement | | ≤ 1,000 ccm | ≤ 2,000 ccm | > 2,000 ccm |
|---|---|---|---|---|
| IPI rate | Gasoline | 7% | 13% | 25% |
| | FFV | 7% | 11% | 18% |
| Minimum sale price (incl. IPI) | Gasoline and FFV | 25,000 BRL | 30,000 BRL | 60,000 BRL |
| IPI | Gasoline | 1,636 BRL | 3,451 BRL | 12,000 BRL |
| | FFV | 1,636 BRL | 2,973 BRL | 9,153 BRL |
| | **FFV tax advantage** | **0 BRL** | **478 BRL** | **2,847 BRL** |

Multiplying these tax advantages with the number of registered vehicles, it can be stated that these tax advantages reduced revenues with IPI considerably in a phase of increasing registration of new passenger cars in the past years. While total IPI revenues from registration of new passenger cars increased from 1.8 billion USD (2006) to 3 billion USD (2008) and thus about 67%, tax losses increased from 145 million USD (2006) to 294 million USD (2008) and thus about 102% (see figure 22 below and table 54 in the annex). Share of tax losses on theoretical revenues from IPI on passenger cars if FFV received the same tax treatment increased slightly from 8.3% to 8.9% between 2006 and 2008. Thus, tax renouncement by the federal government due to reduced IPI for FFV was considerable in the past years.

Since sales of passenger cars increased considerably in the last years, growing IPI revenues concealed the fact that these revenues could have been even higher without the tax advantages for FFV. Additionally, public discussions focused on the even larger tax advantage of the "carros populares" and its justification, since some cars with 1.0 litre engines and top equipment reach prices above 50,000 BRL. The government wants to change the regulation and is supported by some car manufacturers that do not

[73] Sales of alcohol cars declined steadily and in 2007 amounted to only 107. Therefore, alcohol cars are included in the numbers of FFV.

produce any cars in Brazil with an engine displacement below 1,400 ccm like GM, Honda, Toyota and Peugeot/Citroën. But at the same time Fiat, VW and Ford benefit from this tax regulations and the government is very cautious with regard to any modifications because of the populist appeal of the "carro popular" (Cleide Silva 2007). In the case of the tax advantages for FFV, these are not questioned by the automotive industry since all manufacturers offer these cars at the present. But despite the increasing motorisation of the low middle class because of the "carros populares", possession of a passenger car follows the unequal income distribution in Brazil. In greater São Paulo, the poorest quartile (less than 600 BRL mensal family income) owned 7% of the total income and possessed 9% of total passenger cars in this area in 1997. The richest quartile (more than 1,951 BRL mensal family income) owned 60% of the total income and hold 52% of total passenger cars (Companhia do Metropolitano de São Paulo 2000). Therefore, promoting the purchase of passenger cars through tax reductions means an income transfer to privileged classes, which of course is not only true for countries like Brazil.

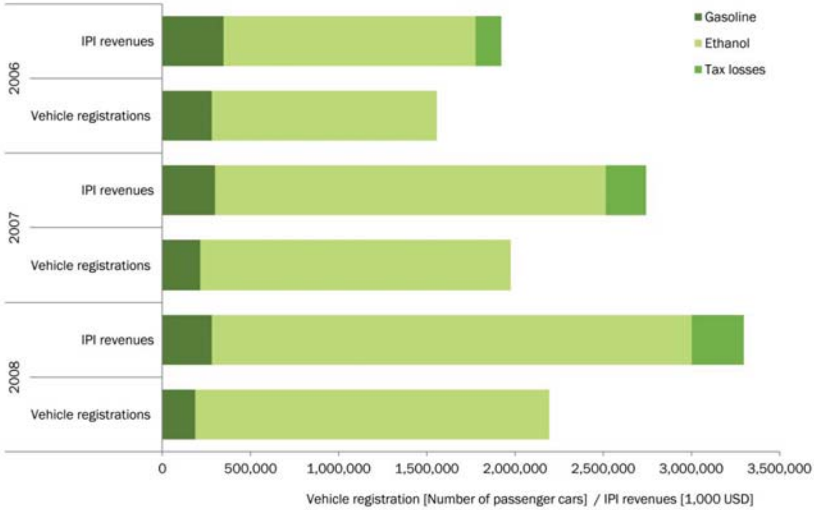


Figure 22 – Renouncement on revenues from IPI for passenger cars in Brazil 2006-2008 (Giersdorf, based on (Emiliani and Figueiredo 2005; Morelli 2005; Presidência da República 2004c; Presidência da República 2006c; Presidência da República 2008e; Presidência da República 2009b; Associação Nacional dos Fabricantes de Veículos Automotores 2009a; Associação Nacional dos Fabricantes de Veículos Automotores 2009b))

### 4.2.7. Conclusion

Sugar and ethanol production increased considerably in Brazil and the amount of ethanol produced per hectare doubled since the beginning of *PROALCOOL* due to increased agricultural and industrial efficiency. But sugarcane cultivation area also increased sevenfold making Brazil the largest producer of sugarcane derived products (sugar and ethanol) worldwide. The expansion of ethanol production into the Central-West region demands for investments in transport infrastructure and some projects like the construction of an ethanol pipeline already have been announced but several delays occurred in the past years and none of these projects has been implemented yet. These projects shall also help to boost ethanol exports to the US, Europe and Asia which increased in the past years. But due to the success of the FFV, the increasing domestic market will continue to be the most important market for the next years. Due to relatively low production costs and tax reductions, ethanol can compete with gasoline as neat fuel at petrol stations in Brazil. However, the competitiveness is limited to regions with ethanol production and/or good infrastructure and differs considerably between Brazilian states. While in São Paulo state, all year long ethanol prices are more than 70% below gasoline prices, ethanol is almost never the more feasible option in Pará state for example. Considering the world market ratio of international sugar and gasoline prices in the past years, sugar would have been the more feasible option for the producers most of the time. But there was also a period in 2007/08 with low sugar and high crude oil prices, during which ethanol production for the world market would have been more feasible and interestingly this coincides with a phase of increasing ethanol exports, although reasons for this may be diverse. However, as could be described already in chapter 3.1.7.3 domestic policy support such as tax advantages for ethanol as a neat fuel shape the development of ethanol production and consumption. These tax advantages result in increasing tax losses especially but not exclusively in São Paulo state, the most important production and consumption market in Brazil. Tax losses for São Paulo state amounted to 1.6 billion USD in 2008, representing one fourth of theoretical tax revenues with fuels for spark ignition engines if ethanol fuel would receive the same tax treatment as gasoline fuel. Tax losses due to reduced taxation of FFV also increased and amounted to 294 million USD in 2008 for Brazil. Of course, these tax losses may be justified by positive impacts caused by the substitution of the fossil gasoline fuel by the renewable ethanol fuel. However, only a detailed assessment of Brazilian sugarcane, sugar and ethanol production could provide evidence for this justification but this assessment has not been realised yet and would be also beyond the scope of this study. Analysing recent trends in light vehicle sales and fuel consumption in Brazil, it is obvious that FFV and ethanol fuel are not only substituting gasoline cars and gasoline consumption but are also contributing to the increasing overall light vehicle fleet and fuel demand in Brazil. Since total revenues with fuels for spark ignition engines increased in São Paulo state from 3.84 billion USD (2006) to 4.78 billion USD (2008) and total revenues with IPI for Brazil from 1.8 billion USD (2006) to 3 billion USD (2008), tax reductions for ethanol fuel and cars are not being discussed controversially in Brazil until now. Thus, more than a substitute, ethanol has become an additional or complementary energy carrier to gasoline. As an emerging market, Brazil is confronted with the challenge to meet increasing energy demand in many sectors and especially in the transport sector considering the continental dimensions of the country. However, the success of ethanol fuel may narrow the focus and important alternatives to an individual transport infrastructure based on combustion engines such as investments in waterways and railways may not be sufficiently considered.

## 4.3. Biodiesel production, distribution, and consumption in Brazil

Biodiesel can be obtained through the physical-chemical transformation of vegetable oils, animal fats, residual oils and fats and fatty acids from public sewages. In this study, only vegetable oils and animal fats shall be considered. Vegetable oils and animal fats consist of a mixture of different triglycerides, also called fatty acids, and this specific mixture influences the characteristics of the oils or fats. The most common fatty acids are palmitic acid, stearic acid, oleic acid, linoleic acid and linolenic acid. Vegetable oils can be used directly as a fuel – called straight vegetable oil (SVO) or pure plant oil (PPO) – in diesel motors, but the high viscosity and low oxidation stability create some problems in modern compression ignition engines with direct injection (Schmiedel 2005). To avoid these problems, the main constituent of vegetable oils and animal fats – the complex and long chain triglycerides – are transformed into short chain alkyl esters in a chemical process called transesterification or alcoholysis. Since the fatty acid alkyl esters have characteristics similar to those of petroleum diesel, they are called generically biodiesel.

## 4.3.1. Production of biodiesel in Brazil

### 4.3.1.1. Feedstock for biodiesel production in Brazil

Table 30 – Oilseed crops cultivation and vegetable oil production in Brazil, 2010/11 (Giersdorf, based on (Ministry of Agriculture, Livestock and Food Supply 2009; Companhia Nacional de Abastecimento 2010; Associação Brasileira das Indústrias de Óleos Vegetais 2010c; Companhia Nacional de Abastecimento 2011a))

| Oilseed crop | Soybean | Oil palm[74] | Castor | Cottonseed | Sunflower |
|---|---|---|---|---|---|
| Cultivated area (ha) | 24,033,900 | 57,000 | 242,800 | 1,304,700 | 73,400 |
| Seed production (t) | 70,296,900 | 570,000 | 183,400 | 3,040,000 | 110,100 |
| Seed productivity (kg/ha) | 2,925 | 10,000 | 755 | 2330 | 1500 |
| Oil content of the seed (%) | 18-20 | 26-32 | 42-56 | 18-26 | 40-50 |
| Medium oil productivity[75] (kg/ha) | 556 | 2,700 | 370 | 513 | 675 |
| Oil production[76] (t) | 6,820,000 | 148,000 | (< 90,000) | (< 669,000) | (< 50,000) |

Due to the continental dimensions of Brazil and a variety of different climates, there are various vegetable oils that could be used for biodiesel production theoretically. There are several oil seed crops in Brazil as well as innumerous native palm species whose fruits contain vegetable oil (Universidade Federal de Lavras 2010). But only few feedstocks are suitable for biodiesel production. First of all, some of the oil seed crops that are mentioned frequently as a feedstock option like jatropha curcas or various palm trees are not yet available in large quantities since they are not cultivated commercially. These raw materials may represent an interesting option for biodiesel production in small and decentralised production units or even in industrial scale in the future. But intensive agricultural research and development should precede a more widespread – and not necessarily more intensive – cultivation of these crops especially when cultivated by small farmers. Second, the different vegetable oils have a different composition of the main fatty acids, and thus chemical-physical characteristics of the esters differ as well. Because of this, some fatty acid alky esters may not comply with specifications for biodiesel or will only do so by a different treatment of the vegetable oil before the transesterification process or by adding some additives to the esters after the transesterification process. This may increase the production cost of the biodiesel and reduce the technological and/or economic feasibility of the biodiesel derived from a certain vegetable oil. Last but not least, most of the vegetable oils with a potential for biodiesel production have alternative uses in the foodstuffs, the pharmaceutical, the cosmetics or other industries. Therefore, competition about the limited feedstock "vegetable oil" may lead to increasing international prices of the most important vegetable oils thus increasing the opportunity costs of the biodiesel production. Thus, despite the theoretical availability of various oilseed crops in Brazil, biodiesel production concentrates on a few vegetable oils and animal fats. The vegetable oils used for biodiesel production in Brazil may not necessarily be the vegetable oils with the best agricultural, technological or economical feasibility, but they are a result of the agricultural, technological, economical and political his-

[74] Only data available for 2007
[75] Considering crop production and average theoretical oil content.
[76] Oil production for soybean and oil palm are real production values. For castor, cottonseed and sunflower, values are maximum potential oil production when 100% oil extraction rate from seeds considering average oil content.

torical developments and current decisions in Brazil. This is why focus in this study will be on soybean, oil palm, castor, and cottonseed, sunflower and animal fats in the following chapters.

**Soybean** is a plant cultivated traditionally in Eastern Asia, especially in China. It was introduced in southern Brazil in the 1960s in order to supply animal feedstuff for the growing Brazilian pig breeding and poultry farming. Since Brazilian soybean harvest lasts from February to April when there is no harvest in the northern hemisphere, export-driven soybean cultivation grew rapidly in Brazil since the 1970s (Empresa Brasileira de Pesquisa Agropecuária 2008). Until then, soybean cultivation was limited to regions with a temperate climate but the *Empresa Brasileira de Pesquisa Agropecuária* (*EMBRAPA* - Brazilian Agricultural Research Organization) developed new varieties adapted to the tropical climate. Nowadays, soybeans are cultivated all over Brazil with a concentration in the Central-West and the Southern region. The soybean is composed of proteins (40%), carbohydrates (35%), oil (20%) and ash (5%), soybean meal is an important animal feed due to this high protein content. Despite the relatively low oil content of the soybean, soy oil is the most important vegetable oil fur human nutrition due to the high production volume of soybeans. Soy oil is composed mainly of linoleic acid (49%), oleic acid (26%) and linolenic acid (11%) (Roth and Kormann 2002, 152).

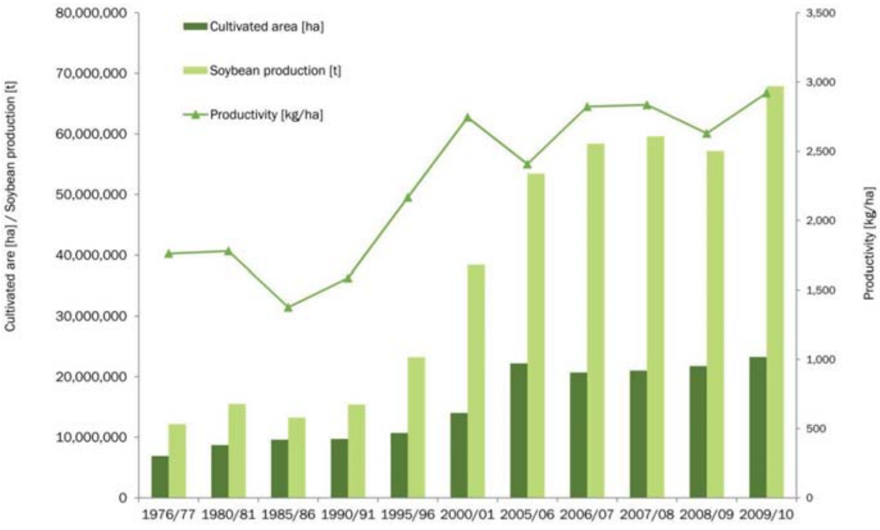


Figure 23 – Soybean production in Brazil 1976/77-2010/11 (Giersdorf, based on (Ministry of Agriculture, Livestock and Food Supply 2009; Companhia Nacional de Abastecimento 2010; Companhia Nacional de Abastecimento 2011a))

In 2010/11, soybeans plantations covered 24 million ha of arable land, this corresponded to 39% of the planted area with annual crops (61 million ha) and 2.8% of total area of Brazil (851 million ha) (see figure 23 below and table 55 in the annex). Soybeans are being cultivated in almost every Brazilian state, but 25% of the production is concentrated in the state of Mato Grosso in the Central-West region, followed by the southern states of Paraná and Rio Grande do Sul (Ministry of Agriculture, Livestock and Food Supply 2009; Companhia Nacional de Abastecimento 2010; Companhia Nacional de Abastecimento 2011a). In 2010/11, Brazil produced 70 million tons of soybeans, being the second largest soybean producer worldwide after the United States (91 million tons) and ahead of Argentina (50 million tons) and China (15 million tons) (United States Department of Agriculture 2011d). In 2010, 24 mio t of soybeans were exported, 35 million tons were processed in Brazil to 27 million tons of soymeal and 7 million tons of soy oil. Brazil exported 14 million tons of soymeal and 1.6 million tons of soy oil in 2010 (Associação Brasileira das Indústrias de Óleos Vegetais 2010c).

Theoretically, there are a lot of native palm trees in Brazil that could be used for oil and biodiesel production due to is fruits with a high oil content, like the babassu palm *(Attalea speciosa)*, the buriti palm (*Mauritia flexuosa)* or the macaúba palm (*Acrocomia aculeata*). However when palm oil is mentioned in the context of commercial vegetable oil and biodiesel production, normally this refers to the oil of the **African palm oil** (also called dendê in Brazil, *Elaeis guineensis*). This palm specie is native to tropical Africa, but it is being cultivated all over the world due to its high oil yield (3,000 – 6,000 kg/ha), now being the most important source of vegetable oil, together with soy oil.

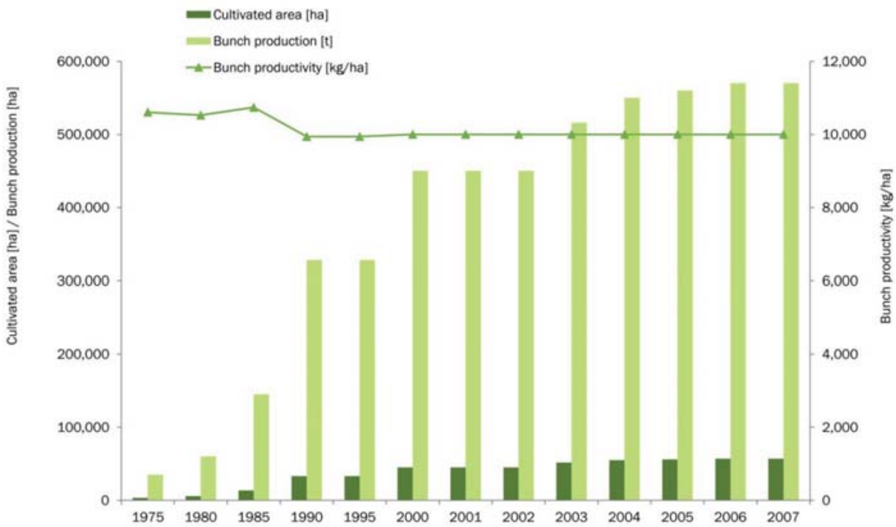


Figure 24 – Palm oil production in Brazil 1975-2007 (Giersdorf, based on (Ministry of Agriculture, Livestock and Food Supply 2009, 70))

In 2010/11, Indonesia was the largest producer of palm oil (22 million tons) followed by Malaysia (18 million tons) and Thailand (1.5 million tons) (United States Department of Agriculture 2011e). Brazilian palm oil production, which is concentrated in the states of Pará and Bahia, is quite modest with 148,000 t cultivated on 57,000 ha in 2007[77] (Ministry of Agriculture, Livestock and Food Supply 2009, 70). Oil palm cultivation area has increased slightly in Brazil in recent years but does not surpass 100,000 ha, this is less than 0.15% of the total agricultural area (see figure 24 and table 56 in the an-

[77] The African oil palm requires a humid tropical climate with temperatures between 24° and 32° C and annual rainfall above 2,000 mm. These climate conditions are widespread in Brazil in the Amazon basin and partly at the North-eastern coast. Limited palm oil cultivation in Brazil may be explained by the need for complex logistic and high initial investment. Agricultural production and industrial processing have to be integrated due to the quick acidification of the fruits after harvesting. The vegetation cycle of palm trees in general is long thus restricting the commercial cultivation to well capitalized farmers or agricultural enterprises. Oil palms yield fruits four to five years after plantation and harvesting is economically feasible for 20 to 25 years (Kaltner et al. 2005, 57).

nex). The area under cultivation is divided equally between the state of Pará and the state of Bahia. But the state of Pará accounts for 85% of the fruit production with yields of 20,000 kg/ha. Productivity of oil palms in Bahia is low because many palms are growing without any cultivation and the plantations for industrial use have exceeded the vegetative cycle of 25 years and needed to be renovated (Secretaria de Agricultura, Irrigação e Reforma Agrária do Governo do Estado da Bahia 1998).

The **castor oil plant** (called "mamona" in Brazil, *Ricinus communis*) is probably indigenous to the south-eastern Mediterranean region and Eastern Africa where it was cultivated already by the Egyptians about 4,000 BC (Bärtels 2003, 366). Due to its resistance to drought, castor oil plant establishes itself even on wasteland and can be found everywhere in the tropics between 40° N and 40° S. The plant prefers temperatures between 20° and 30° C, elevated solar radiation, annual rainfall above 500 mm and soils with a medium texture without danger of water logging. However, the distribution of the precipitation is more crucial than the amount, with 400-500 mm rainfall until the flowering and relative air humidity below 60% during the rest of the vegetative cycle (Napoleão Esberard de M. Beltrão et al. 2003, 2). The plant produces seeds, which contain between 42 and 56% of castor oil, 20% of proteins as well as cellulose, carbohydrates, water and alkaloids. The press cake can be used as a fertiliser or animal feed when detoxicated, since the exocarp of the seeds contains the highly toxic protein ricin. The castor oil is composed almost exclusively of ricinoleic acid (84-91 %), that has a hydroxyl functional group which causes castor oil to be polar with a high solubility in ethanol but no solubility in hydrocarbons. Due to these unique characteristics castor oil is a valuable feedstock for numerous applications in cosmetics, pharmaceutical, and manufacturing industries (Kaltner et al. 2005, 57).

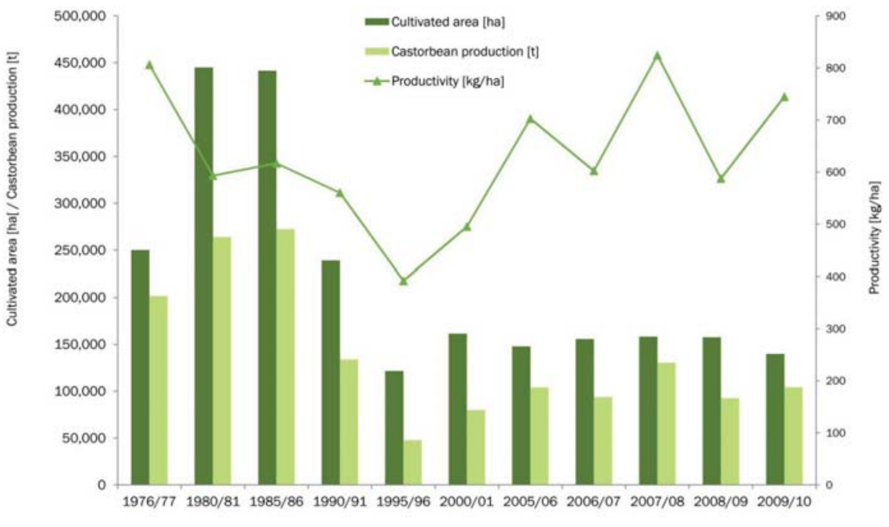


Figure 25 – Castor bean production in Brazil 1976/77-2010/11 (Giersdorf, based on (Ministry of Agriculture, Livestock and Food Supply 2009; Companhia Nacional de Abastecimento 2010; Companhia Nacional de Abastecimento 2011a)

In the 1970s and 1980s, Brazil was the largest producer of castor beans, with an annual production of 200,000 tons of castor beans and crop productivities between 800 and 1,200 kg/ha, but production declined due structural and cyclical events (see figure 25 and table 57 in the annex) (Napoleão Esberard de M. Beltrão et al. 2003, 2). In 2008, Brazil was the third largest producer behind India (1,123,000 tons) and China (220,000 tons) (FAOSTAT 2010a). Castor cultivation is concentrated in the Northeast, especially in the state of Bahia, which is responsible for more than two third of the national production. There is also some production in the states of Minas Gerais and São Paulo. These plantations yield more than 1,500 kg/ha while crop productivity in the Northeast does not surpass 800 kg/ha (Ministry of Agriculture, Livestock and Food Supply 2009; Companhia Nacional de Abastecimento 2010). Within the National Biodiesel Programme, various efforts have been undertaken in order to increase the productivity in the Northeast by incorporating adapted technologies, but climatic conditions may restrict the potential crop productivity in the semi-arid regions in the Northeast without irrigation.

The **cotton plant** (*Gossypium*) is native to tropical and subtropical regions of Africa, Asia and South America. It is one of the oldest cultivated plants of mankind principally because of its soft, staple fibre that grows around the seeds of the cotton plant and that is used for textile production. But the fibre is not the only economically important product of the cotton plant. Beside the 40% of lint, the cottonseed also contains 60% of kernel, from which kernel oil can be extracted. Oil content of the kernel is about 18 - 26 %, the other main component being proteins (30-40%). After the removal of gossypol, a naturally occurring toxin that protects the cotton plant from insect damage, cottonseed oil can be used for human alimentation and the press cake can be used as animal feed. Cottonseed oil is rich in linoleic acid (49-58%), palmitic acid (22-26%) and oleic acid (15-20%) (Roth and Kormann 2002, 118). Cultivation of cotton requires a long frost-free period, plenty of sunshine and annual rainfall from 600 to 1,200 mm.

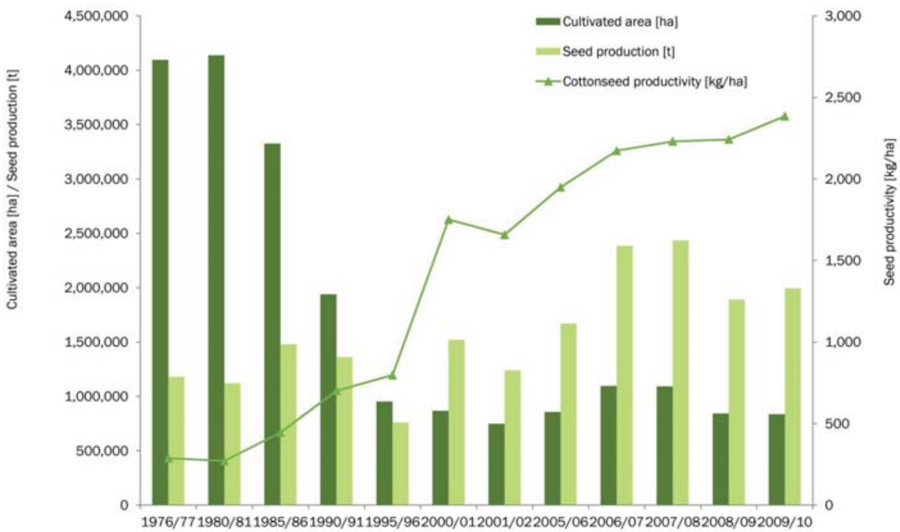


Figure 26 – Cottonseed production in Brazil 1976/77-2010/11 (Giersdorf, based on (Ministry of Agriculture, Livestock and Food Supply 2009; Companhia Nacional de Abastecimento 2010; Companhia Nacional de Abastecimento 2011a))

In 2008, Brazil was the sixth largest cottonseed oil producer in the world with 260,000 tons, behind China (1,725,000 tons), India (980,000 tons), Pakistan (403,000 tons), the United States

(368,900 tons) and Uzbekistan (315,800 tons) (FAOSTAT 2010b). In 2010/11 cottonseed was cultivated on 1,304,700 ha in Brazil with a strong concentration in the states of Mato Grosso and Bahia. The production of 5 million tons of cotton yielded 1.9 million tons of cotton lint and 3 million tons of cotton kernel, resulting in a crop productivity (seed and lint) of 3,825 kg/ha, and a seed productivity of 2,330 kg/ha (Ministry of Agriculture, Livestock and Food Supply 2009; Companhia Nacional de Abastecimento 2010; Companhia Nacional de Abastecimento 2011a). Medium seed (as well as crop) productivity increased while cultivated area declined dramatically in the past 30 years (see figure 26 and table 58 in the annex).

This development can be explained through the introduction of new international varieties, the advance of mechanised sowing and harvesting and the elimination of non-competitive small farmers with little technology and low productivities. This was accompanied by a delocalization of cotton cultivation from states like São Paulo, Paraná, Minas Gerais and Ceará to the state of Mato Grosso (Gonçalves and Ramos 2007, 34). Theoretically, the cotton kernel could yield 669,000 tons of cottonseed oil and would make cottonseed oil the second most important resource of vegetable oil in Brazil behind soybean oil[78]. Although worldwide cottonseed oil production only ranges in sixth position in world supply of vegetable oils – behind palm oil, soybean oil, rapeseed oil, sunflower seed oil and even peanut oil – it is of relative importance in Brazil and represents an interesting feedstock for biodiesel production.

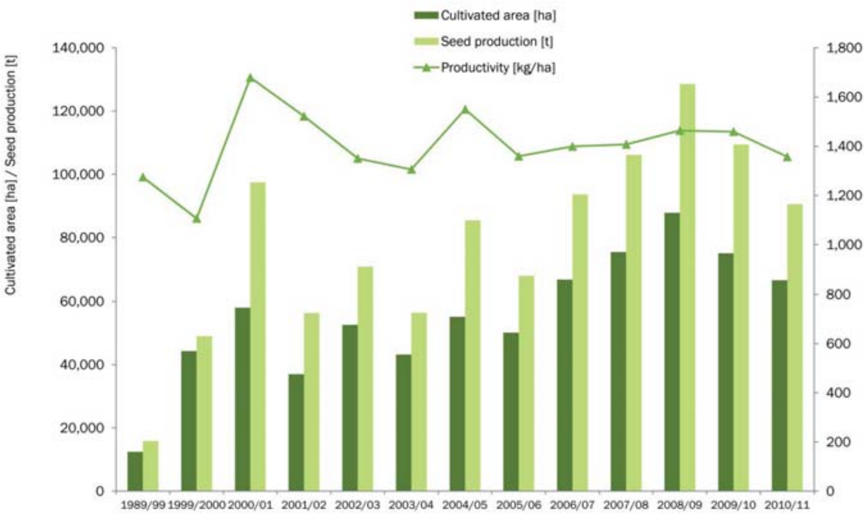


Figure 27 – Sunflower seed production in Brazil 1976/77-2010/11 (Giersdorf, based on (Ministry of Agriculture, Livestock and Food Supply 2009; Companhia Nacional de Abastecimento 2010; Companhia Nacional de Abastecimento 2011a))

The **sunflower** (*Helianthus annuus*) is an annual plant native to the Americas. In the 16th century it was taken to Europe and Asia where it was used as an ornamental plant and a source for vegetable oil. Sunflowers grow best in fertile, moist, well-drained soil with a lot of mulch, plenty of sun and enough water. The sunflower seeds contain 40-50 % oil that is very valuable for human nutrition because of its un-

[78] Since there is no data for the amount of cottonseed oil production in Brazil, production volume only can be estimated.

saturated fatty acids (linoleic acid (62-70%) and oleic acid (15-25%) (Roth and Kormann 2002, 153). Major sunflower seed producers in 2010/11 were the European Union (7 million tons), Ukraine (6.8 million tons), Russia (5.5 million tons) and Argentina (2.8 million tons) (United States Department of Agriculture 2011a). With a worldwide production of 11.3 million tons in 2010/11, sunflower seed oil ranged fourth in the world supply of vegetable oils (United States Department of Agriculture 2011a; United States Department of Agriculture 2011d).

Sunflower cultivation increased in Brazil in the past ten years, though from a quite low basis (see figure 27 and table 59 in the annex). With 73,400 ha cultivated in 2010/11, sunflower accounts for about 0.1% of the total cultivated area in Brazil. It can be planted either during Brazilian winter/spring or in crop rotation after the harvest of crops like soybeans or corn in the summer/autumn (Leite et al. 2007). Sunflowers are mainly cultivated in the states of Mato Grosso, Rio Grande do Sul and Goiás.

Beside the described vegetable oils, **animal fats** from cattle or chicken processing represent a potential feedstock for biodiesel production in Brazil. In 2009, Brazil had a livestock of about 200 million cattle and 1 billion poultry. During 2009, 28 million cattle were slaughtered in Brazil. With a tallow yield of 15-19 kg/cow, annual beef tallow production may reach about 500,000 tons in Brazil (Sistema IBGE de Recuperação Automática - SIDRA 2010). Beef tallow consists mainly of oleic (47%), palmitic (26%) and stearic acid (14%). In order to control the share of free fatty acids[79], the tallow has to be treated immediately after slaughtering. High quality tallow with few free fatty acids is used for soap production, for cooking, as foodstuff and for biodiesel production.

### 4.3.1.2. Oil extraction and biodiesel production process

Vegetable oil can be extracted in large scale plants with a processing capacity of 4,000 tons per day oilseed or in small plants with 0.5-25 tons per day oilseed capacity. In small decentralised plants, the oilseeds are cleaned, dried, shelled and then pressed in expellers. The raw oil is filtrated and centrifuged in order to increase purity of the oil. This processing method is quite simple and cheap, but oil yields only reach 70%. Large scale plants use solvents (hexane) to extract the residual oil content of the oilseeds in addition to pressing or only use the extraction method. The oil yield of the combined pressing/extraction process is 99% (Hartmann and Kaltschmitt 2003, 116). Through vaporization and distillation, the solvent is separated from the raw oil and used again for the process. In order to get high quality vegetable oil for nutrition or other uses, the raw oil has to be refined subsequently. Phosphoric or citric acid is added to the raw vegetable oil in order to separate phosphatides, proteins, pigments and other impurities. The free fatty acids and the phosphoric acids are usually neutralised through the addition of caustic soda[80]. Then, the oil is being bleached by adding bleaching clay and finally deodorised with water vapour (GEA Mechanical Equipment / GEA Westfalia Separator n.a.). The refined oil can be used as edible oil or as feedstock for biodiesel production. Vegetable oil for biodiesel production does not necessarily receive the same pre-treatment as edible oil, but high quality vegetable oil improves the biodiesel production process and the quality of the biodiesel itself. The typical process to adapt the vegetable oil to conventional compression ignition engines is called transesterification (see figure 28). Vegetable oils and animal fats are chemically composed of triglycerides, long chains where the trivalent alcohol glycerol is esterified with three fatty acids. In order to obtain a low molecular structure with characteristics similar to these of mineral diesel, the glycerol is substituted through three univalent al-

[79] Free fatty acids are fatty acids that are not attached to other molecules such as glycerol for instance. Because of this, they are highly reactive with oxygen and can make vegetable oils and animal fats turn rancid.
[80] Some vegetable oils, such as sunflower or corn oil contain waxes (long-chained fatty alcohols). To remove these waxes, a process called winterisation can be combined with the neutralisation.

cohols (methanol or ethanol) (Hartmann and Kaltschmitt 2003, 116). The transesterification may be realised in a batch, a semi-continuous or a continuous process. The basic chemical reaction of the biodiesel production process is quite simple and remains the same regardless the feedstock. When not used refined vegetable oil, pre-treatment of the feedstock may be necessary (Lurgi GmbH 2008).

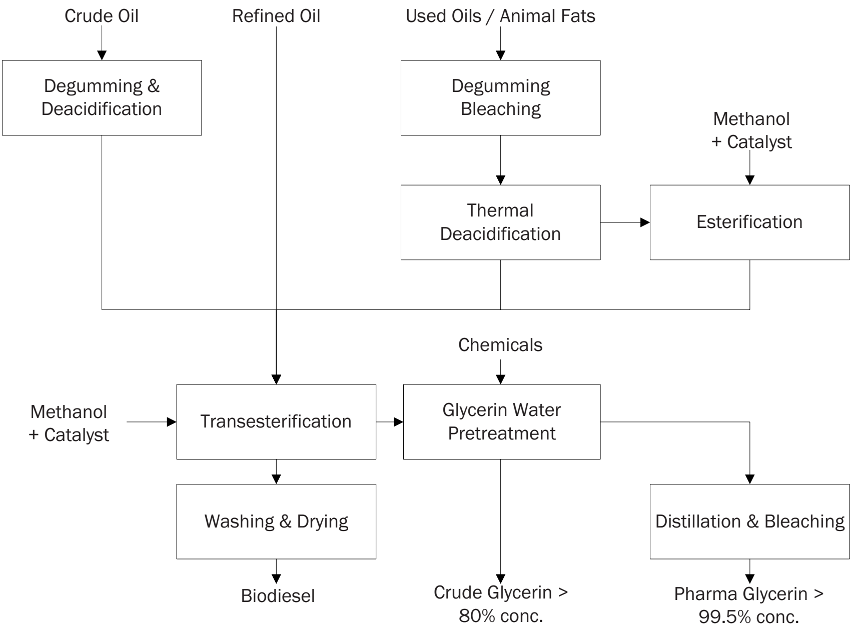


Figure 28 – Flow chart of biodiesel production process (Hamilton 2004)

For low-cost feedstocks with a high content of free fatty acids like animal fat or crude palm oil, esterification[81] is recommended before the transesterification process (Chongkhong et al. 2007). The transesterification results in a light phase with fatty acid alkyl esters – called biodiesel – and a heavy phase with glycerine water. The biodiesel is washed in order to remove by-product components and then dried. The surplus alcohol contained in the glycerine water is removed in a rectification column and used again in the next reaction process. After evaporation, glycerine may be used either as crude glycerine or glycerine water may be distilled and bleached and yield pharmaceutical glycerine with a purity of >99.5 %. Glycerine has several applications in the cosmetic and pharmaceutical industry, as well as in the food processing and the chemical industry. Every ton of feedstock yields one ton of biodiesel and approximately 90 kg of pharmaceutical grade glycerine or 5 kg of technical-grade glycerine (Lurgi GmbH 2008).

Table 31 – Overview of consumption of raw material for 1 000 kg of biodiesel

[81] Different from transesterification, in which the alkoxy group of an ester compound is exchanged with another alcohol, esterification is a chemical reaction in which two reactants (typically an alcohol and an acid) form an ester as the reaction product.

| Type | Material | Lurgi 2007 | Haas et al. 2006 | Unit |
|---|---|---|---|---|
| Feedstock | Rapeseed oil (degummed and deacidified) | 1,000 | - | kg |
| | Soybean oil, degummed | - | 1,010 | kg |
| Alcohol | Methanol | 96 | 101 | kg |
| Catalysts | Sodium Methylate 100% NaOCH3 | 5 | 12.6 | kg |
| | Hydrochloric acid (37%) HCl | 10 | 7.2 | kg |
| | Sodium Hydroxide (Caustic soda) NaOH (50%) | 1.5 | 5 | kg |
| | Nitrogen | 1 | - | $Nm^3$ |
| Auxiliaries | Steam | 320 | - | Kg |
| | Cooling water | 25 | - | $m^3$ |
| | Electrical Energy | 12 | 30 | kWh |
| | Process water | 20 | 33 | kg |
| | Natural gas | - | 57 | $m^3$ |

### 4.3.1.3. Development of vegetable oil and biodiesel production in Brazil

Soybeans are the most important crop and by far the most important oilseed in Brazil. In 2006/07, soyoil represented 76% of Brazilian edible oil supply of 7.4 million tons, followed by tallow (8%), lard (5%), cottonseed oil (3%) and palm oil (2%). Butter, corn oil, castor oil, sunflower oil and rapeseed oil represented each more or less 1% of total supply. Thus, when analyzing the structure of the Brazilian oil processing industry, a special focus is on the **soy oil** industry. The spatial distribution of the soybean processing industry differs substantially from the spatial distribution of the soybean production. The states of Paraná and Rio Grande do Sul – where soybean production expanded already in the 1970s – still hold 21% respectively 17% of the total installed crushing capacity in Brazil (Associação Brasileira das Indústrias de Óleos Vegetais 2010a). The states of Mato Grosso and Mato Grosso do Sul – where soybean cultivation expanded only in the 1980s – are still underrepresented when it comes to the installed capacity. However, in order to minimise transport costs, installed capacity in Mato Grosso almost triplicated between 2001 and 2009 contributing to an overall increase in crushing capacity in Brazil. This was also an answer to federal policies trying to promote the industrialisation and the value aggregation of the exports of the soybean complex (Ministério da Agricultura, Pecuária e Abastecimento 2007b, 72). At the same time, underutilisation rate of the installed crushing capacity increased from about 30% in 2001 to about 48% in 2009/10[82] (Associação Brasileira das Indústrias de Óleos Vegetais 2010a; Associação Brasileira das Indústrias de Óleos Vegetais 2010b). The processing soy oil industry is very concentrated: 24% of the installed crushing capacities are hold by huge multinational and international groups with a daily processing capacity above 3,000 tons/day, big groups with 1,500 to 3,000 tons/day hold another 45%, medium enterprises hold 27% and small enterprises 4% of the crushing capacity (Fraga and Medeiros 2005, 5). The problem of underutilisation of existing crushing capacities is not restricted to the soy complex. The **castor bean** processing industry holds a crushing

[82] Considering 300 days for plant operation. Installed capacity: 2001: 107,950 tons/day; 2009: 165,299 tons/day. Processed soybeans: 2001/02: 22,773,000 tons; 2009/10: 30,779,000 tons

capacity of 500,000 tons/year. Since castor bean production did not exceed 210,000 tons/year in the last years, underutilisation was about 60% (Maia et al. 2006, 19). The Brazilian **palm oil** processing industry is dominated by one large player, Agropalma in the state of Pará. This company was responsible for 72% of the national palm oil production in 2005. Besides Agropalma, there are only eight other processing companies that do not produce more than 10,000 tons of palm oil each (Kaltner et al. 2005, 58).

In January 2011, 69 biodiesel plants had an authorisation from the regulatory agency ANP to produce biodiesel. The annual production capacity of these plants amounted to 6.2 billion litres of biodiesel[83]. 42% of the installed capacity was located in the Central-West region, 25% in the South, 18% in the Southeast, 12% in the Northeast and 3% in the North. The groups with the largest installed and authorised capacity as of January 2011 were: Granol[84] with two plants and 556 million litres, Brasil Ecodiesel with four plants that sum up to 518 million litres, Caramuru with two plants and 450 million litres, and Petrobras with three plants and 434 million litres installed capacity. This means that until now mainly Brazilian companies have invested in the biodiesel production, but with ADM, Agrenco, Naturoil and other multinational companies that plan to invest there is also an international interest in biodiesel production in Brazil (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2011c).

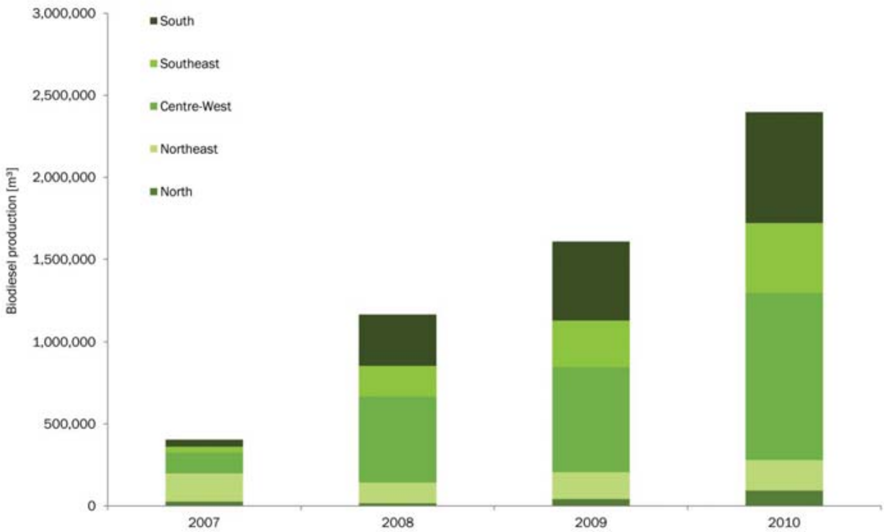


Figure 29 – Biodiesel production by region in Brazil 2007- 2010 (Giersdorf, based on (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2011b)

Brazilian biodiesel production amounted to 2.4 billion litres in 2010 and thus showed a sharp increase from 404 million litres in 2007, 1.2 billion litres in 2008 and 1.6 billion litres in 2009. Before the eco-

[83] Assuming 360 days of biodiesel production per year.
[84] Granol is a Brazilian soy processing enterprise with 5 industrial units and a crushing capacity of 1.9 Mio. t soybeans.

nomic crisis of 2008, many biodiesel producers preferred to pay penalty payments for breaching the contracts rather than losing the opportunity to sell their soy at very high prices (Brito 2008). But following the harvest time of Brazilian soy (February to May) and due to declining international prices for soy oil and other vegetable oils in the second semester of 2008, biodiesel production increased very strongly and the government decided to raise biodiesel blend several times until the B5 target was introduced from January 2010 on (see table 60 in the annex). Soy oil continues to be the main feedstock for biodiesel production. Since December 2008, participation of soy oil on biodiesel production ranged between 70% and 90% and of animal fat (beef tallow) between 20% and 10%. Participation of other vegetable oils - except of cottonseed oil with about 2% - is negligible (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2010d). Thus, the political goal to diversify the feedstock for biodiesel production in accordance with the regional availability of the oilseed crops has not been reached and will not be reached in the near future. Feedstock participation obviously reflects the vegetable oil production structure in Brazil. This is not surprising considering that the large national and multinational enterprises with soy as their core business like Granol, Caramuru and ADM are also the largest biodiesel producers. Other enterprises like Biocapital and especially the cattle processing company Bracol/Bertin mainly use animal fat, but also soy oil. Even Brasil Ecodiesel that tried to implement biodiesel production from alternative raw materials like castor oil produced by small farmers is mainly relying on soy oil as a feedstock. The predominance of soy oil coincides with the geographical concentration of the biodiesel production in the Centre-West where soy cultivation is concentrated. In 2010, this region was responsible for 42% of Brazilian biodiesel production, followed by the South (28%), the Southeast (18%), the Northeast (8%) and the North (4%). While absolute biodiesel production increased in the North, the Centre-West, the South and the Southeast between 2007 and 2010, it stagnated in the North, since Brasil Ecodiesel had to close two plants. However, the commercial inauguration of the Petrobras plants (Quixadá, CE and Candeias, BA) and the plant of Comanche (Ex-IBR) (Simões Filho, BA) could partly compensate the decline (see figure 30 and table 61 in the annex).

### 4.3.2. Distribution of diesel and biodiesel in Brazil

As regulated in Law 11.097, biodiesel can be sold only blended with diesel fuel and not as neat fuel to the petrol stations. The biodiesel producers can sell the biodiesel either to a refinery or directly to the distribution companies. Similar to the collection for ethanol, biodiesel is collected mainly by tank trucks and then brought to the distribution centres of the different companies. In 2009, there were 508 distribution centres, 204 in the Southeast, 110 in the South, 64 in the Centre-West, 74 in the Northeast and 56 in the North (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2010e, 132). Most of the biodiesel plants are close to the 64 bases of the most important distribution company Petrobras. But there are also some biodiesel plants located far away from distribution centres, like the plants of Brasil Ecodiesel in the interior of the states of Tocantins and Bahia, the plant of Caramuru in Goiás and some plants in the interior of Mato Grosso. This increases transport distances, but in may cases the choice of the plant location was determined by the location of existing soy oil facilities (Granol, Caramuru, ADM, etc.). In addition to the transport from the biodiesel plants to the distribution centres, the over proportional biodiesel production capacities in the Centre-West and the Northeast ask for transports of B100 (or B2) between the different regions. The North, the Northeast and the Southeast have to import biodiesel from other regions, while the Centre-West and the South are net exporters of biodiesel (see figure 30 and table 62 in the annex).

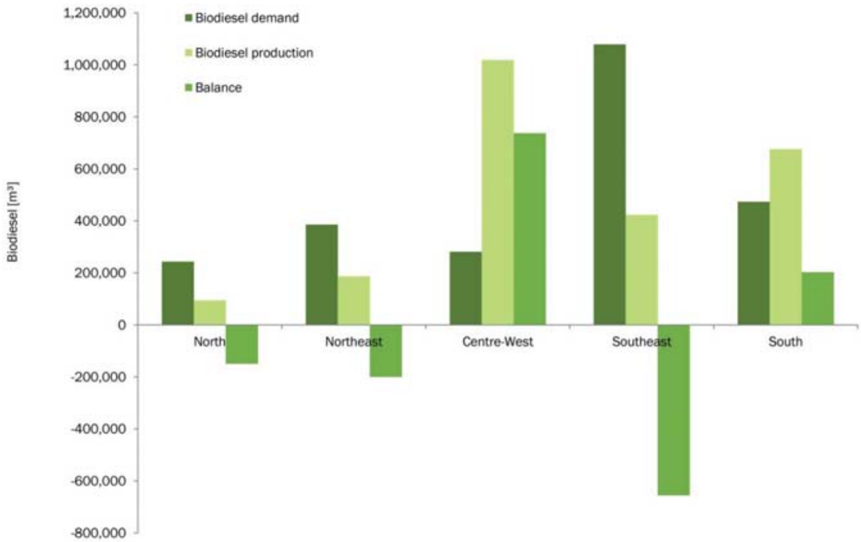


Figure 30 – Demand, production and balance of biodiesel in Brazilian regions, 2010 [m³] (Giersdorf, based on (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2011a; Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2011b))

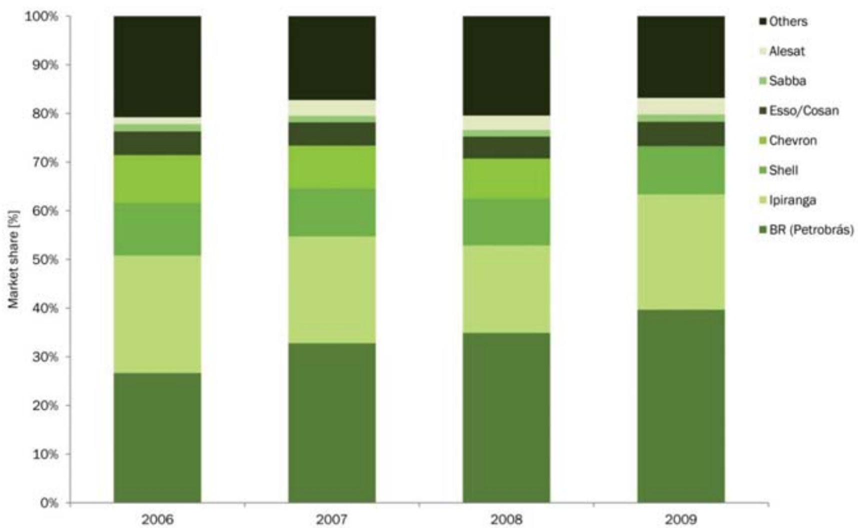


Figure 31 – Market shares of distribution companies on diesel fuel sales 2006-2009 (Giersdorf, based on (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2006a; Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2007b; Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2008a; Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2009a; Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2010e))

In the case of the Southeast, tank-trucks could transport biodiesel in one and ethanol in the other direction, since this region is a net exporting region of ethanol. But since ethanol acts as a solvent, the tanks have to be cleaned and vaporised in a time-intensely process after biodiesel transports, thus increasing the costs of such a solution (Campello 2007). Compared to the gasoline and especially to the hydrous alcohol market, the diesel fuel market is more homogeneous, and with sales of 44 billion litres in 2009 also larger than the market for Otto-engine fuels. The most important actor Petrobras-BR could increase its market share from 27 % (2006) to 40 % (2009) in the past years (see figure 31).

## 4.3.3. Consumption of biodiesel in Brazil

Vegetable oils can be used directly in compression ignition engines, but high viscosity, low oxidation stability and high gas adsorption require modifications of compression ignition engines. Thus, vegetable oils are adapted to the use in diesel engines by transesterification in which the high viscosity of the vegetable oils is reduced and the volatility is increased. The temperature, the type and the concentration of the catalysts, the relation between alcohol and ester, the purity of the feedstock, the distillation and the presence of anti-oxidants determine the reaction process and the quality aspects of the biodiesel (Schmiedel 2005). The parameters of the transesterification have to be controlled carefully, since the biodiesel needs to comply with specifications when being used as a fuel (see chapter 3.2.2.7). But there are also some parameters that are closely linked to the feedstock used in the process such as density, viscosity and oxidation stability (see table 32).

Table 32 – Characteristic values of diesel fuel and selected fatty acid methyl esters (Giersdorf, based on (Santos 2004; Schmiedel 2005; Kumar, Maheswar and Reddy 2009))

| Biodiesel based on | Density at 15.5°C (g/cm³) | Viscosity at 40° C (mm²/sec) | Cetane number | Heating value (MJ/l) | Diesel equivalent | Cloud Point °C |
|---|---|---|---|---|---|---|
| Palm oil | 0.88 | 5.70 | 62.00 | 33.26 | 0.92 | 13.00 |
| Soy oil | 0.88 | 4.08 | 46.20 | 35.18 | 0.98 | 2.00 |
| Castor oil | 0.93 | 13.75 | >51 | 36.66 | 1.02 | -23.00 |
| Sunflower oil | 0.88 | 4.60 | 49.00 | 33.53 | 0.93 | 1.00 |
| Animal fat | 0.88 | 4.10 | 58.00 | 34.99 | 0.97 | 12.00 |
| Rapeseed oil | 0.88 | 4.40 | 49.60 | 32.65 | 0.90 | -1.00[85] |
| Cotton oil | 0.85 | 6.10 | 53.00 | 34.44 | 0.95 | -2.00 |
| | | | | | | |
| Diesel fuel | 0.85 | 2.0-4.5 | 51.00 | 36.08 | 1.00 | -1.80 |

Although biodiesel **viscosity** is lower than that of the vegetable oil, it remains higher than that of diesel fuel in most cases. This affects the volume flow and injection spray characteristics in the engine and may damage the injection pump drive systems. Due to the extraordinary high viscosity of castor oil (239.39 mm²/s), biodiesel from castor oil has to be blended with biodiesel from other raw materials when used as B100 or blended with at least 60% of diesel fuel in order to comply with specifications

[85] Pour Point

(Maia et al. 2006, 7). The **lower heating value** of biodiesel reduces the power (between 5 and 7% for B100 compared to fossil diesel) and varies depending on the percentage share of biodiesel in the blend. An important parameter for the use of biodiesel is the **cloud point**, the temperature at which dissolved solids are no longer completely soluble and precipitate as a second phase making the liquid appear cloudy. Because of a high cloud point, biodiesel from palm oil and animal fat can not be used in temperate climates without blending it with biodiesel from other feedstock (Schmiedel 2005). **Oxidation stability** of biodiesel is lower than that of diesel fuel. The oxidation and polymerisation may lead to the formation of deposits and congestion of the fuel filter. Most of the vegetable oils contain natural anti-oxidants but these are removed during the distillation of the biodiesel. Because of this, anti-oxidants are added to the biodiesel increasing the costs of the biodiesel. Especially biodiesel from soy and from sunflower oil have low oxidation stability due to their high content of the polyunsaturated linoleic acid (Haupt and Bockey 2006, 4).

However, all the parameters described above depend on the quality of the process reaction and the feedstock and can be partly improved. But there are also some general chemical-physical characteristics of the biodiesel that can not be modified. Due to the polar group of its alkyl esters, biodiesel acts as a **solvent** and may solve deposits in the engine that may congest the fuel filter. Tanks and conductors from **materials** like copper, lead and zinc have to be replaced through materials from stainless steel and aluminium for blends with more than 5% biodiesel since they promote oxidation of biodiesel. Due to its low vapour pressure, biodiesel that got into the engine at low load mode can not evaporate like diesel fuel and therefore dilutes the **motor oil**. The intervals of oil change have to be shortened to prevent the motor from damage (Haupt and Bockey 2006, 4). Biodiesel has a **high lubricity** and can replace sulphur that is normally used in diesel fuel in order to increase the lubricity (Schmiedel 2005).

While gasohol and ethanol fuel are almost exclusively used for transport, the final consumption of diesel and blends with biodiesel is diversified. In Brazil, the transport sector was responsible for 82% (35.8 billion litres), the agricultural sector for 15% (6.5 billion litres) and the industrial sector for 2% (0.8 billion litres) of the final energy consumption of 43.5 billion litres of diesel fuel in 2009 (Empresa de Pesquisa Energética 2010, 50). Diesel consumption amounted to 34.6 billion litres in 2000 and 43.5 billion litres in 2009, representing an annual increase of 2.6%. Brazil managed to reduce imports of crude oil and derivates in the past years by expanding considerably crude oil extraction and production of derivates. But despite an increasing diesel production, Brazil continues with a diesel fuel deficit of at least 2 billion litres and still has to import diesel fuel. Depending on international prices, the annual net deficit with these imports oscillated between 766 million BRL (2003) and 4.6 billion BRL (2008) (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2011a). Because of this, the Brazilian government developed strategies to reduce dependency on diesel fuel imports and one element of this strategy was the production of biodiesel and the introduction of the mandatory blending with diesel fuel in 2008.

### 4.3.4. Economics of biodiesel production in Brazil

For the calculation of the biodiesel production costs, revenues for the sale of the by-product glycerol and three different types of costs have to be considered:

- Investment costs or capital-related costs (e.g. capital investment, financing, lifetime of the plant),
- consumption-related costs (e.g. biomass costs, auxiliaries, loading hours), and

- operation-related costs (e.g. labour, service and operation, maintenance).

Since there is no detailed data for biodiesel production costs in Brazil, biodiesel production costs can only be estimated by using a process model (Haas et al. 2006). For the model production facility with a production capacity of 38 million litres of biodiesel based on degummed soybean oil in the United States, **total investment or capital costs** amounted to 11.35 million USD (details see table 63 in the annex). For a detailed calculation of the capital costs of a biodiesel production facility in Brazil, data on equity ratio, debt capital, interest rates, inflation rates, period for return of the investment, the project assessment period, etc. would be needed. However, since this goes beyond the scope of the study, the costs for the model production facility shall be assumed for Brazil as well.

As described in chapter 4.3.1.2, the biodiesel production process consists mainly of three different steps: the pre-treatment of the feedstock, if the vegetable oil is not already degummed, the transesterification and the purification of the biodiesel and the co-products. Besides the vegetable oil, raw materials like methanol or ethanol, a catalyst and auxiliaries are consumed and result in the production of 1 000 kg of fatty acid methyl ester and 119 kg of crude glycerine (80% glycerol) (see table 65 in the annex). With 0.46 USD/litre (90% of consumption-related costs of 0.51 USD/litre), the most important cost factor not only of consumption-related but overall biodiesel production costs is the vegetable oil, which has important consequences for the economics of biodiesel production (see table 67 in the annex). For the costs related to the operation of a biodiesel plant, the costs related to labour (two workers per shift, supervisor, maintenance of the plant) and supplies for the operation and the maintenance of the plant are considered and sum up to costs of 0.018 USD/litre (see table 68 in the annex). The three different types of costs sum up to the total biodiesel costs of 0.53 USD/litre. Consumption related costs represent 97% (0.51 USD/litre), while annual capital related costs and operation related costs represent only 6.3% (0.033 USD/litre) respective 3.4% (0.018 USD/litre) of the subtotal biodiesel costs not considering the revenues of 0.034 USD/litre for the sale of the glycerol (see table 33). Since the vegetable oil alone represents 87% of the subtotal costs, it is obvious that a change in the feedstock and/or feedstock costs/prices signify major changes in overall production costs.

Table 33 – Biodiesel production costs for a 38 million litres biodiesel facility in the US (Haas et al. 2006)

| Type | Material | USD/litre biodiesel | % of total costs |
|---|---|---|---|
| | General and administration (0.5% of annual capital costs) | 0.001 | 0.3% |
| | Property taxes (0.1% of annual capital costs) | 0.000 | 0.1% |
| | Property insurance (0.5% of annual capital costs) | 0.001 | 0.3% |
| | Depreciation (10% of annual capital costs) | 0.030 | 5.7% |
| Subtotal | Annual capital-related costs | 0.033 | 6.3% |
| Feedstock | Soy oil | 0.462 | 87.2% |
| Alcohol | Methanol | 0.025 | 4.8% |
| Catalysts | Sodium Methylate 100% NaOCH3 | 0.011 | 2.1% |
| | Hydrochloric acid (37%) HCl | 0.001 | 0.2% |
| | Sodium Hydroxide (Caustic soda) NaOH (50%) | 0.003 | 0.5% |
| Auxiliaries | Electrical Energy | 0.001 | 0.3% |

| | | | |
|---|---|---|---|
| | Process water | 0.000 | 0.0% |
| | Natural gas | 0.008 | 1.6% |
| | Wastewater treatment | 0.001 | 0.2% |
| Subtotal | Consumption-related costs | 0.513 | 96.8% |
| Labour | Operating (2 persons/shift) 12.5 USD/h, 8000h/a | 0.005 | 1.0% |
| | Maintenance | 0.001 | 0.2% |
| | Supervisory | 0.003 | 0.6% |
| | Fringe benefits (40% of labour costs) | 0.004 | 0.7% |
| Supplies | Operating supplies (20% of operating labour costs) | 0.001 | 0.2% |
| | Maintenance supplies (1% of annually capital costs) | 0.003 | 0.6% |
| Subtotal | Operation-related costs | 0.018 | 3.4% |
| Subtotal costs | | 0.564 | 106.4% |
| Revenues | Glycerol | -0.034 | -6.4% |
| Total | | 0.530 | 100.0% |

Since there is no information available on production costs for vegetable oils in Brazil, the international commodity prices for the vegetable oils were used and computed as costs for the vegetable oils in Brazil. This may be methodologically problematic for biodiesel plants that are annexed to oil extraction plants and where costs for vegetable oil could be calculated based on the oilseed costs and the processing costs (and revenues for by-products such as oil meal or cake, etc.). But many biodiesel plants have to acquire vegetable oil on the Brazilian market so that the calculation based on the opportunity costs – the market prices for the vegetable oils – is also close to the economic reality of many plants. Other costs and revenues for or from biodiesel production were not changed for the Brazilian context due to the rather small impact on overall production costs.

The following analysis should be seen only as an approximation to the economic feasibility of biodiesel production in Brazil. Diesel prices at fuel stations amounted to 1.00 USD/litre between 08/2008 and 07/2009 in Southeast Brazil, with slightly higher and lower prices in other Brazilian regions (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2010c). Discounting federal and state taxes, the costs for the blended biodiesel, distribution and retail costs and profits, the price of the diesel ex-refinery amounted to 0.53 USD/litre, representing 53% of the end consumer price (Petrobras - Petróleo Brasileiro S.A. 2009). Biodiesel production costs can be compared with the diesel price ex-refinery to analyse feasibility of biodiesel production in Brazil. Independent of the feedstock, biodiesel production costs are higher than diesel prices ex-refinery. In the case of castor biodiesel, production costs are even above diesel end consumer prices, including taxes and profits. For every other feedstock, biodiesel could be also commercialised as 100% biodiesel and with a tax reduction in order to guarantee competitiveness with fossil diesel (see figure 32).

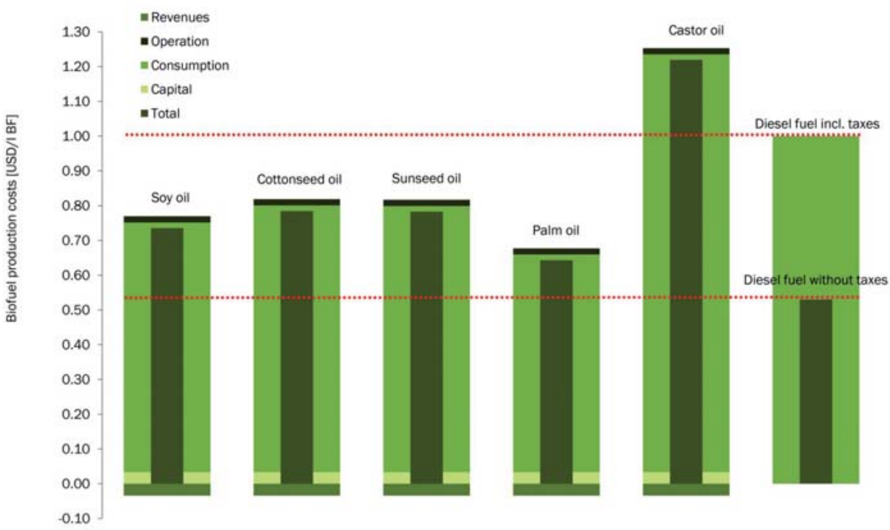


Figure 32 – Comparison of biodiesel production costs for a 38 million litres biodiesel facility based on international commodity prices for vegetable oils for July 2009 (Giersdorf, based on (Haas et al. 2006; Petrobras - Petróleo Brasileiro S.A. 2009; Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2010c; Companhia Nacional de Abastecimento 2011b; United States Department of Agriculture 2011b))

Theoretical biodiesel production costs were also calculated in a study in 2005 based on production costs for the oilseeds and on the market prices of the oilseeds – not the vegetable oil. Due to different production costs and market prices of the oilseeds in different Brazilian regions as well as different capacities of the considered model biodiesel plants, biodiesel production costs ranged between 0.31 and 0.72 USD/litre FE for soy biodiesel and between 0.26 and 0.73 USD/litre FE for cotton biodiesel (Geraldo Sant'Ana de Camargo Barros et al. 2006, 40). These costs are considerably lower than the biodiesel production costs calculated based on the American model plant. But in the study, market prices and feedstock costs were considered for the period from July 2004 to June 2005. In 2008/09, market prices for all feedstocks were considerably higher in local Brazilian currency than 2004/05 due to international price increases and a considerable appreciation of the Brazilian Real against the US-Dollar. This illustrates the difficulty to calculate production costs for Brazilian biodiesel and that overall economic feasibility of the biodiesel production depends on the opportunity and not the production costs especially since Brazil is one of the most important producers and exporters of vegetable oil. In the past years, international prices for vegetable oils underwent a sharp increase and subsequent decline, so the economic feasibility of biodiesel production – which also depends on the international diesel fuel prices – may have changed considerably during the considered period (see figure 33).

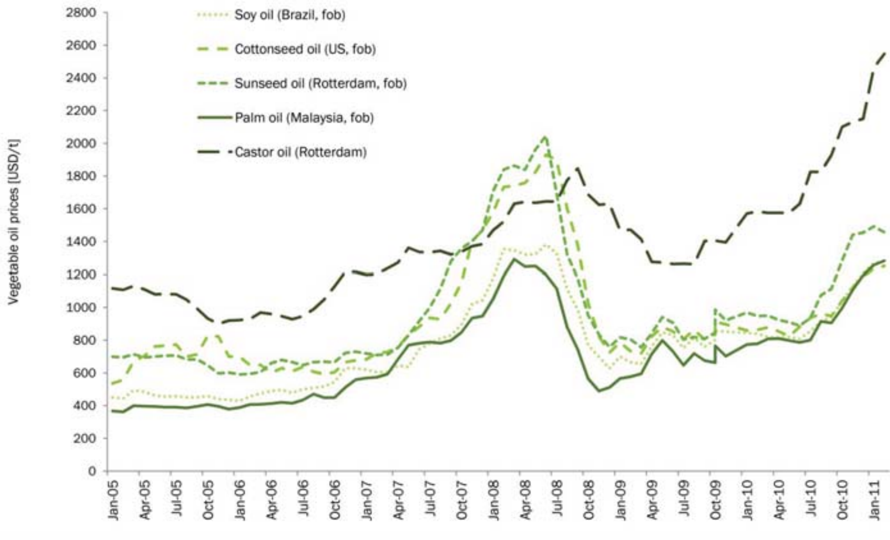


Figure 33 – International prices for selected vegetable oils from 01/2005 to 02/2011 (Giersdorf, based on (Companhia Nacional de Abastecimento 2011b; United States Department of Agriculture 2011b))

Prices of the raw material (since soybeans are exported directly without further value adding), prices of other products (since soybeans are cultivated for the production of soymeal and soy oil is often considered a “by-product”) and international import tariff systems (since tariffs for soybeans are lower than for soy oil) could be considered for a more detailed analysis, but the general comparison of vegetable oil and diesel fuel prices is already a good indicator for the opportunity costs of the biodiesel production. Thus, analogous to ethanol (see chapter 4.4.4.3), a graphic illustrating the combinations of spot prices for vegetable oils and diesel fuel in the past years can be constructed[86]. The line of indifference represents any price relation between vegetable oil and biodiesel on a given day where economic viability of biodiesel and the respective vegetable oil is equal. The area on the left demarks price relations favourable to the production of biodiesel, while the area on the right demarks price relations favourable to the commercialisation of the vegetable oil in the food market. Most price combinations do not favour the production of biodiesel using vegetable oil. With diesel fuel prices above 700 USD/ton between October 2007 and October 2008, prices of most of the vegetable oils increase and even surpass 1500 USD/ton between March and July 2008. But for palm oil and soy oil, biodiesel production would have been more beneficial several times for the period considered. While in the case of soy oil this is true for the price relations before August 2006, biodiesel production from palm oil would have been favourable in 2008 when palm oil prices did not entirely follow the sharp increase of the other vegetable oils and returned faster to the level anterior to the price hike in 2007/08 (see figure 34 and table 34 below and table 69 in the annex).

[86] If feedstock costs for soyoil amount to 520 USD/ton for 1 t of biodiesel, representing 87% of the subtotal biodiesel costs, biodiesel costs then amount to 597 USD/ton. Thus roughly 77 USD/ton can be added to the vegetable oil costs in order to present the costs for transesterification (incl. revenues from glycerol sales).

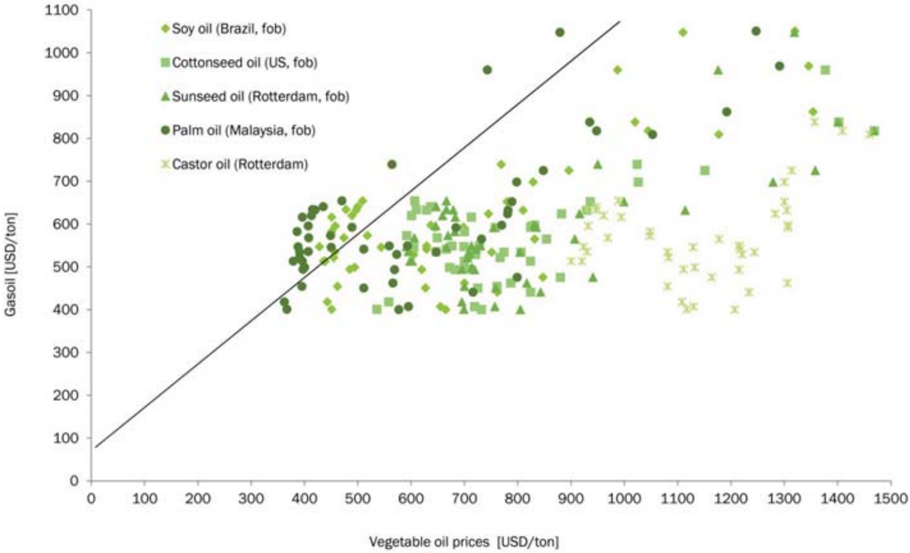


Figure 34 – World market ratio for biodiesel production 2005-2010 (Giersdorf, based on (United States Energy Information Administration 2010b; Companhia Nacional de Abastecimento 2011b; United States Department of Agriculture 2011b))

Table 34 – International diesel and vegetable oil spot prices in USD/ton 2005-2010[87] (Giersdorf, based on (United States Energy Information Administration 2010b; Companhia Nacional de Abastecimento 2011b; United States Department of Agriculture 2011b))

| Date | Diesel (US, fob, low sulfur) | Soy oil (Brazil, fob) | Cottonseed oil (US, fob) | Sunseed oil (Rotterdam, fob) | Palm oil (Malaysia, fob) | Castor oil (Rotterdam) |
|---|---|---|---|---|---|---|
| Jan-05 | 412 | 451 | 536 | 699 | 367 | 1,117 |
| Jul-05 | 518 | 457 | 774 | 708 | **391** | 1,081 |
| Jan-06 | 552 | **428** | 699 | 591 | **388** | 923 |
| Jul-06 | 682 | **500** | 637 | 647 | **435** | 947 |
| Jan-07 | 504 | 620 | 683 | 719 | 569 | 1,215 |
| Jul-07 | 661 | 780 | 936 | 999 | 789 | 1,300 |
| Jan-08 | 799 | 1,177 | 1,580 | 1,709 | 1,053 | 1,460 |
| Jul-08 | 1,180 | 1,326 | 1,897 | 1,692 | 1,115 | 1,756 |
| Jan-09 | 456 | 700 | 787 | 817 | **566** | 1,306 |
| Jul-09 | 519 | 751 | 806 | 804 | 647 | 1,244 |
| Jan-10 | 639 | 845 | 860 | 969 | 774 | 1,571 |
| Jun-10 | 641 | 808 | 882 | 889 | 787 | - |

87 Data in bold letters represent price relations favourable for biodiesel production.

### 4.3.5. Critical analysis of selected biodiesel support policies

According to the regulatory agency *ANP*, foreign currency savings due to import substitution was estimated to amount to 1.4 billion USD in 2010 with the 5% mandatory biodiesel blend (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2009c). No details for the calculation of these savings were presented, but when the biodiesel sold during the auctions in 2010 (2.355 billion litres) is multiplied with the average price of the imported diesel fuel (0.57 USD/litre), this sums up to 1.34 billion USD in 2010 (see table 35 below). Thus, the projection by *ANP* was quite accurate. But when analysing selected biodiesel support policies it should be considered that biodiesel consumption may also present economic costs for the government through tax losses and for the end consumers through higher diesel end consumer prices caused by the mandatory blend of biodiesel.

Table 35 – Foreign currency savings due to the substitution of diesel fuel imports in Brazil 2006-10 (Giersdorf, based on (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2011a))

| Year | Imported diesel fuel [m³] | Costs of imports [USD] | Import price [USD/m³] | Biodiesel sold at auctions [m³] | Foreign currency savings [USD] |
|---|---|---|---|---|---|
| 2006 | 3,545,075 | 1,746,709,380 | 493 | 156,250 | 76,986,620 |
| 2007 | 5,099,406 | 3,019,515,780 | 592 | 731,250 | 432,995,709 |
| 2008 | 5,829,309 | 5,140,940,867 | 882 | 1,040,000 | 917,189,070 |
| 2009 | 3,515,042 | 1,672,498,470 | 476 | 1,565,000 | 744,645,471 |
| 2010 | 9,006,996 | 5,131,079,360 | 570 | 2,355,000 | 1,341,589,570 |

#### 4.3.5.1. Tax losses due to reduced taxation of biodiesel

Due to reduced taxation of biodiesel, the government renounced on 11 million USD in 2006 and 147 million USD in 2010, representing 0.3% (2006) respective 2.3% (2010) of total theoretical revenues with diesel sales if biodiesel had the same tax burden as diesel fuel (see table 36).

Table 36 – Biodiesel and diesel fuel sales and tax revenues 2006-2010 (Giersdorf, based on (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2011a))

| | Unit | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|
| Biodiesel sold at auctions | 1,000 litres | 156,250 | 731,250 | 1,040,000 | 1,565,000 | 2,355,000 |
| Total diesel sales (incl. biodiesel) | 1,000 litres | 39,008,397 | 41,558,180 | 44,763,952 | 44,298,463 | 49,239,039 |
| Biodiesel share (vol.) | % | 0.40 | 1.76 | 2.32 | 3.53 | 4.78 |
| Tax revenues from biodiesel | 1,000 USD | 3,246 | 12,599 | 46,542 | 68,836 | 126,220 |
| Revenues from diesel (excl. biodiesel) | 1,000 USD | 3,885,998 | 4,562,956 | 4,557,472 | 4,317,590 | 6,033,967 |
| Total revenues | 1,000 USD | 3,889,244 | 4,575,554 | 4,604,014 | 4,386,425 | 6,160,187 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Theoretical revenues without reduced taxes for biodiesel | 1,000 USD | 3,900,057 | 4,636,378 | 4,654,802 | 4,459,379 | 6,307,370 |
| Tax losses | 1,000 USD | - 10,814 | - 60,824 | - 50,788 | - 72,953 | - 147,183 |
| Share of tax losses on theoretical revenues | % | 0.28 | 1.31 | 1.09 | 1.64 | 2.33 |

Despite increasing biodiesel consumption, tax losses decreased in 2008 compared to 2007 due to reduction of *CIDE* on diesel fuel in May 2008 from 0.07 BRL/litre to 0.03 BRL/litre (see chapter 3.2.2.5). This temporary tax reduction for fossil diesel in 2008 resulted in tax losses of 1.2 billion BRL (638 million USD). Thus, compared to these tax losses, tax renouncement due to tax benefits for biodiesel is smaller, but still significant. With regard to this temporary tax reduction it is interesting that Petrobras raised diesel fuel prices 15% at the refineries when the tax reduction was announced by the government. The diesel prices had been adjusted by Petrobras in September 2005 for the last time and thus refinery prices for diesel were 30% below international market prices in April 2008 (Pires 2008). The reduction of the contribution and the raise of the diesel prices at the refineries were announced by the minister of Finance Guido Mantega after a reunion with President Luiz Inácio Lula da Silva, some other ministers and the president of Petrobras. This shows clearly the political influence on price policies of the oil company Petrobras, since it was the first time after the liberalisation of the fuel sector that such a raise was announced by a government member (O Globo Online 2008). However, since *CIDE* is designed as a regulative contribution (a pigouvian tax rather than a revenue tax) with the goal to subsidise fuels during high fuel price periods, these losses are not considered a problem by the government since it uses this tool to control inflation and not to increase tax revenues in the fuels sector (Cavalcanti 2006, 58).

## 4.3.5.2. Increasing diesel prices due to mandatory blending

With the increasing mandatory blending of biodiesel, prices for the diesel at the fuel stations increased since biodiesel prices paid at the auctions were considerably above the prices for fossil diesel at the refineries. Based on the biodiesel mandatory blend, the medium biodiesel prices at the auctions and the diesel prices at the refineries, the theoretical additional costs of biodiesel consumption can be calculated. These costs can be either passed on to the end consumers through higher diesel prices or these costs can reduce profit of refineries, distribution companies and retailers. The reduced tax burden on biodiesel was subtracted from these costs, since these costs are already considered as tax losses for the government. The biodiesel sold annually at the auctions increased up to 2.35 billion litres in 2010 with a medium price of 1.23 USD/litre biodiesel. Costs for biodiesel summed up to 2.89 billion USD, but savings of 147 million USD due to reduced taxes for biodiesel can be subtracted from these costs. While costs for the 2.1 billion litres of substituted diesel would have amounted to only 1.37 billion USD with a medium diesel price ex-refinery of 0.64 USD/litre, additional costs for biodiesel consumption amounted to 1.37 billion USD in 2010 for the end consumers (see figure 35 and table 70 in the annex). Thus, while tax losses due to tax reductions are relatively small, the additional costs paid by the end consumers – since the refineries, distribution companies and retailers probably passed on these costs – may be quite considerable. In 2010, prices for the diesel with 5% vol. biodiesel added could be 4.4% above theoretical diesel prices if no biodiesel would have been added. However, empirical evidence of such a price increase will not be analysed within this study since methodologically it would be very difficult to analyse price developments during the last years and to identify any direct causality between many factors that can contribute to price oscillations of diesel fuel at petrol stations in Brazil.

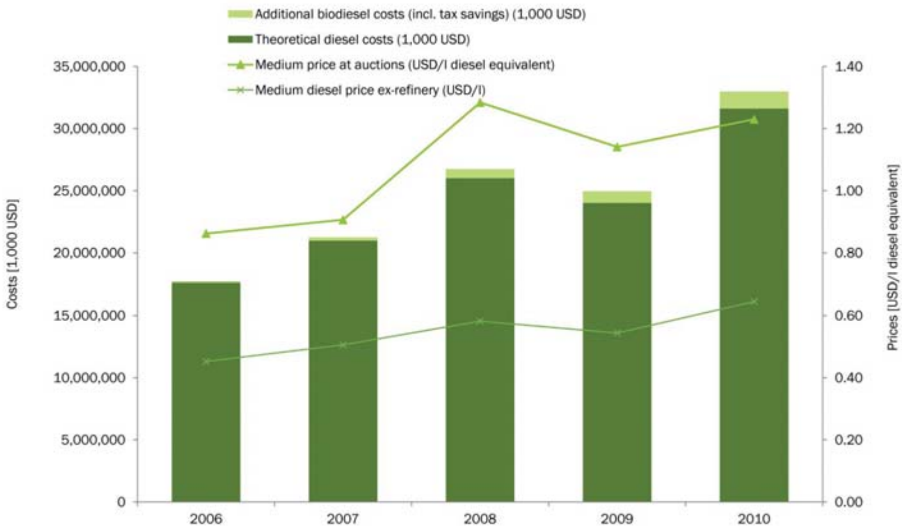


Figure 35 – Theoretical additional costs due to biodiesel mandatory blend 2006-2010 (Giersdorf, based on (Petrobras - Petróleo Brasileiro S.A. 2009; Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2010c; Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2010f; Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2011a))

### 4.3.6. Conclusion

Brazilian biodiesel production increased rapidly from 69 million litres (2006) to 2.4 billion litres (2010) and managed to meet the demand for the 5% mandatory blend earlier than initially planned. One factor that contributed to this fast development was the decline of the international prices for soy commodities in 2008/09 following the international economic crisis. Although several vegetable oils could be used theoretically for biodiesel production in Brazil, between 70% and 90% of the biodiesel is based on soy oil. With 24 million ha soy cultivation area and 70 million tons of soybeans in 2010, Brazil is the largest soy producer worldwide and since especially the soy processing industry in South Brazil has large idle capacities, biodiesel demand could be easily met by this sector. Thus, biodiesel production is also concentrated in the soy producing regions of the Central-West and the South which have to "export" biodiesel especially to the Southeast, but also to the Northeast and the North. Since the biodiesel production process is not very complex, the biodiesel costs mainly depend on the vegetable oil costs. Considering that not only soy oil but all vegetable oils used for biodiesel production are internationally traded commodities, the biodiesel production costs follow the volatility of international vegetable oil prices. International prices for vegetable oils underwent a sharp increase and subsequent decline in the past years but even during the decline, biodiesel production would not have been economically attractive according to the world market ratio since diesel prices declined as well. Only during a short period before August 2006 for soy biodiesel and during 2008 for palm oil, biodiesel production would have been more favourable than commercialising the vegetable oils on the world market. But since biodiesel is not offered as a neat fuel in Brazil but only as a blending component for diesel fuel, the market volume is set and the biodiesel producers only supply this guaranteed market. Thus, if international prices for vegetable oils increase or decrease, the maximum biodiesel prices established by the regulatory agency *ANP* have to follow this tendency in order to remunerate biodiesel producers adequately. This caused additional costs for the biodiesel of 1.37 billion USD in 2010 due to the more expensive vegetable oils compared to diesel fuel. This raises the question whether the prices paid for the biodiesel during the auctions caused higher diesel prices for the end consumers. Theoretically, this may have occurred in the past years, but it is very difficult to empirically prove this hypothesis by analysing the development of end consumer prices for diesel fuel in different Brazilian regions due to various factors (changes in taxation in 2008, logistics, international diesel fuel prices, processing capacity of Brazilian refineries, etc.). This aspect also has to be considered when analysing the main economic argument for the support of biodiesel production and use in Brazil, which says that the substitution of imported diesel fuel helped to save foreign currency. Actually these foreign currency savings amounted to 1.34 billion USD in 2010 and may be legitimate to substitute imports of fossil diesel fuel through domestic production of biodiesel based on vegetable oils and to increase income in agricultural value chains. But since by the current support policies income from all diesel consumers is transferred to the biodiesel producers and more especifically to those using soy oil as feedstock it has to be assessed carefully which biodiesel producers and which groups benefit most from these policies.

Comparing the selected economic effects of ethanol and biodiesel support policies there is another aspect that shows that despite the social appeal of the biodiesel programme, the support policies show a social bias with regard to the question who is paying for the additional costs of the biofuels. In the case of ethanol – the fuel for the individual transport – tax losses are the main costs and thus costs are passed on to the general public. For biodiesel, tax exemption is not an important support measure since biodiesel is not used as a neat fuel and since taxation of diesel fuel is relatively low not leaving much tax advantage for biodiesel. Tax losses due to lower taxation of biodiesel only amounted to 147 million USD in 2010. Thus, in the case of biodiesel – the fuel for the public and goods transport system – not tax losses but higher fuel prices are very probably the main costs and that means that the costs are passed on to the end consumers, and not the taxpayers.

# 5. Advocacy coalitions within the biofuel policy arena in Brazil

## 5.1. Advocacy coalitions within the ethanol policy arena in Brazil

Three different coalitons could be identified in the ethanol as well as in the biodiesel sector. Even though the coherence and the influence of these coalitions differ considerably between the two policy arenas, coalitons representing socio-ecological, business and technology oriented belief systems could be identified in both of them.

The ethanol fuel market in Brazil is a well established market with a great continuity in policies and a general consensus about the success of the ethanol programme. No fundamental decisions had been taken during the analysed period and thus only few public statements from the main actors could be interpreted in order to identify their general beliefs. Some actors – like the *Ministério* do *Meio Ambiente, dos Recursos Hídricos e da Amazônia Legal* (*MMA* – Ministry of the Environment, the Water Resources and the Legal Amazon), some academics, the syndicate for migrant workers and NGOs like the landless movement – criticise specific issues of the ethanol production. These actors can be assembled withit what could be called the "Ethanol Social and Environmental Coalition". But compared to the other two coalitons, they do not form a very strong or coherent coalition. The other two coalitons can be identified based on the different perspectives they have when evaluating ethanol as an important energy carrier. But the differences in the belief systems of the main actors that shape the political agenda and the formulation and implementation of the policies are rather subtle. The actors of the "Ethanol Expansion Coalition" are directly involved into ethanol production and emphasise the necessities that arise from the cultivation, harvest, storage and commercialisation of an agricultural product produced by several units spread all over Brazil. Their demands include the necessity for financing of investments, for storage facilities, and the defence of support mechanisms that favour ethanol compared to its competitor gasoline. On the other side, the actors that form the "Control Intensification Coalition" do not have any link with the agricultural sector but with the energy sector or are indifferent to the agricultural needs of the ethanol production. They emphasise the need of a standardised fuel that due to its considerable market share shall contribute significantly to tax revenues and the enforcement of these regulations by strong governmental activities.

### 5.1.1. The "Ethanol Social and Environmental Coalition"

#### 5.1.1.1. Ministério do Meio Ambiente, dos Recursos Hídricos e da Amazônia Legal (MMA) and environmental movements

In the international discussion about biofuels, the *MMA* supported the initiative of the Brazilian federal government within the *World Trade Organization (WTO)* to classify biofuels as an environmental good and thus supports the expansion of the ethanol production and consumption (Net Marinha 2006; Shiki 2007). But at the same time, the ministry is very aware of the fact that biofuels production in Brazil may also create environmental problems and that policies are needed to prevent an accelerated expansion of feedstock cultivation into valuable ecosystems[88] (Domingos 2008). During 2005 and 2006, there

[88] "Ethanol [...] has a very low participation on the Brazilian agricultural area, less than 1%, and it is concentrated in highly developed regions like São Paulo. In these regions, you have environmental benefits, it brings modernisation of the countryside, support for the recuperation of degraded areas and environmental gains. Thus, it is absurd to say that biofuels are a

were controversial discussions in the state of Mato Grosso do Sul about a parliamentary bill authorising the installation and the expansion of sugar and ethanol plants in the drainage basin of the Pantanal[89]. The Federal Minister of the Environment Marina Silva emphasised several times that she considered the parliamentary bill unconstitutional, since a resolution of the *Conselho Nacional do Meio Ambiente* (*CONAMA* – National Council for the Environment) from 1985 prohibits the installation of new ethanol and sugar plants in the drainage basin of the Pantanal (Thuswohl 2005). The legislative assembly of the state of Mato Grosso do Sul – in which most of the area of the Pantanal lies – did not entirely follow this interpretation and voted in 2006 a parliamentary bill that authorised at least the expansion of the production capacities of plants that had already been installed within the Pantanal (Estado do Mato Grosso do Sul 2006). In 2009, a first "approximation for a Ecological-Economic Zoning of the state of Mato Grosso do Sul" was established and this bill created an exception of the general prohibition of the installation of new sugar and ethanol plants for the region of Miranda located right at the southern margin of the Pantanal (Estado do Mato Grosso do Sul 2009). The liberalisation of the expansion of the sugarcane in one core region of the Pantanal represents an environmental threat and can be interpreted as  example for the weak position of environmental concerns and the *MMA* within the national ethanol agenda (Moura de Paulo 2011, 153). Another example of the isolation of the *MMA* within the federal government was the development of guidelines for the agroenergy policies, in which the *MAPA*, the *MCT*, the *MME* and the *MDIC* participated, but not the *MMA* (Ministério da Agricultura, Pecuária e Abastecimento et al. 2005). During the period considered the *MMA* was paralysed several months due to a very controversial restructuring of the *MMA* imposed by a governmental decree in April 2007 in order to reduce direct influence of the *MMA* on environmental licensing and control activities (Presidência da República 2007). In the course of this restructuring, the Minister Marina Silva created a biofuel department within the *MMA* in order to improve the participation of the *MMA* in the national discussion about biofuels (Shiki 2007). However, the *MMA* has very little influence on the ethanol policies and the controversy with the Minister of Agriculture Stephanes about the promotion of sugarcane plantations in degraded areas in the Amazon, the Pantanal and the Atlantic Rainforest was one of the reasons of the resignation of Minister Marina Silva in 2008 (Campana 2008).

The marginalisation of the MMA and environmental issues within the biofuel policies is also mentioned by a representative of the NGO ***Conservation International***. He criticises that the federal government has no joint approach for environmental issues and that his organisation was not invited to participate in the biodiesel working group. With regard to the expansion of the ethanol production and exports *Conservation International* is not opposed to this but proposes that sustainable biofuels shall be included into a package of environmental services offered by Brazil to other nations (Paulo Gustavo de Prado Pereira 2007). With regard to the expansion of sugarcane cultivation, the ***WWF Brasil*** published a study in 2008, in which it was proved that the sugarcane did not advance into the Amazon region, but also alerted for the potential risks on the biodiversity in regions with a high sugarcane concentration and asked for the creation of new conservation units in the Cerrado[90] (WWF Brasil 2008). However, only

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degrading element today. But there is no doubt that it can be tomorrow. There is no doubt that the expansion can be something that creates problems. [...] One thing is to say: "I do not want biofuels to create environmental degradation because I do not want environmental degradation", or to say: "Unfortunately we will not have environmental degradation because this will create trade barriers [for Brazilian exports]". The difference is philosophical, is the perception. In the case of the biofuels, for instance, when we discussed this in various meetings in the core of the government [...] we emphasised that the *MMA* already has a detailed mapping of the sensitive areas from an environmental point of view and that this mapping would be important for guiding governmental policies preventing expansion into these areas, stimulating the expansion in other areas. This was always seen as a restriction."

[89] The Pantanal is a tropical wetland in Brazil, Bolivia and Paraguay with an estimated area of 14 to 20 million hectares.

[90] The Cerrado is a vast tropical savanna ecoregion in the Centre of Brazil and includes forest savanna, wooded savanna, park savanna and gramineous-woody savanna, savanna wetlands and gallery forests. With about 2 million ha it is the second largest of Brazil's major habitat types, after the Amazon.

with crop rotation, organic farming and ecological corridors sugarcane cultivation in areas with a high concentration like the state of São Paulo would be really sustainable. While sugar and ethanol organisations like *UNICA* adopted the environmental discourse – probably also due to the international discussion of the sustainability of biofuels and sugarcane ethanol and the Directive 2009/28/EC of the European Union that set out sustainability criteria for biofuels –, many sugar and ethanol plants do not respect the environmental legislation and continue to clear the riparian forest in sugarcane plantations in the state of São Paulo for example (Kruglianskas 2007; European Parliament 2009).

#### 5.1.1.2. Social movements

The *Movimento dos Trabalhadores Rurais Sem Terra* (*MST* - Movement of the Landless Rural Workers) within the *Via Campesina* movement and the *Comissão Pastoral da Terra* (*CPT* – Pastoral Land Commission) criticise the use of sugarcane and soyoil cultivated in monocultures because of its adverse social and ecological consequences and propagate the principle of food sovereignty, thus promoting the production of food instead of the production of biofuels from foodstuff. More specifically, they fear that the expansion of sugarcane plantations into fallow or unproductive areas will increase illegal appropriation and trade of public areas and impede the distribution of these areas to small famers within the Agrarian Reform[91] (Pastoral Land Commission and Network for Social Justice and Human Rights 2007, 17). In 2007, more than 900 women from Via Campesina occupied a sugarmill of Cargill in the region of Ribeirão Preto in the state of São Paulo state, criticising the air, soil and water pollution, and respiratory deseases caused by the sugarcane monoculture (Felippe 2007). The precarious working conditions of sugarcane cutters, especially in areas where sugarcane is expanding, are criticised as well as the mechanisation of the sugarcane harvest in states like São Paulo since it will increase the pressure on the workers to accept even lower wages (Revers 2007). The monocultures of sugarcane or other cash crops instead of a diversified food production for the local markets and the geographical and capital concentration process within the sugar and ethanol sector are seen as a problem since it increases the vulnerability of the agricultural sector to the development of the international agricultural commody market. A study of the *Rede Social de Justiça e Direitos Humanos* (Network for Social Justice and Human Rights) pointed this out, too, and denounced the expansion of sugarcane plantations into indigenous areas in Brazil, criticised the approval of credit lines for the renewal of sugarcane plantations by the *BNDES* in 2012 after the economic crisis which provoked the bankruptcy of several ethanol plants (Mendonça, Pitta and Xavier 2012).

### 5.1.2. The "Ethanol Expansion Coalition"

#### 5.1.2.1. Ministério da Agricultura, Pecuária e Abastecimento (MAPA)

The *Ministério da Agricultura, Pecuária e Abastecimento* (*MAPA* - Ministry of Agriculture, Livestock and Food Supply) can be considered the most important state actor in the ethanol sector, since it presides the *CIMA* since 2001 – which decides upon the ethanol share in the gasohol blend – and executes the decision by a simple ordinance[92] (Presidência da República 2001a). However, regulative competences

[91] "The cycle of land invasion in Brazil tends to begin with deforestation by large agribusiness, including the use of slave labor, and continues to include cattle farming and soy production. Currently, with the expansion of ethanol production, this cycle is then complemented by sugarcane monoculture. Rather than for ethanol, public agricultural lands should be utilized for the production of food crops, for reforestation of areas degraded by large landowners, and for land reform, in order to meet the historic needs of close to five million families without land."

[92] This competence was once held by the National Petroleum Council during PROÁLCOOL but then transferred several times to other government bodies. At the beginning of the 1990s, it was transferred to the newly created National Fuels Bureau (DNC –

for the federal government are limited compared to the period of *PROÁLCOOL* when state intervention was very strong. With the recent ethanol boom starting in 2003 (and the formulation of the *PNPB*) the minister in office Roberto Rodrigues reorganised the ministry creating a department for agroenergy and created the *Câmara Setorial de Açúcar e Álcool* (Sector Chamber for Alcohol and Sugar) as a deliberative institution for the ministry assembling a broad range of private and state actors. The ministry also published the *Plano Nacional de Agroenergia* (National Plan for Agroenergy)[93] in 2005 and although it did not issue any new regulations, it illustrated the ministry's strategy to clarify the stakes and the competences of the ministry[94] (Strapasson 2007). In the *Plano Nacional de Agroenergia*, the ministry justifies the lower taxation of the hydrated ethanol, the lower *IPI* levies on ethanol and flexible-fuel vehicles and the flexible ethanol share on gasohol blend with the seasonality of the ethanol production, the inexistence of an international market and the weak distribution sector. The last three factors are responsible for supply and price oscillations which have to be minimised since ethanol is considered a strategic product within the national fuel market. There are also some concerns expressed in the document. The regional concentration of the sugar and ethanol plants in the state of São Paulo is evaluated as "alarming" but no measures are proposed. This concentration should be prevented in new areas in which sugarcane cultivation is expanding, but in the vision of the ministry this expansion will not create any problems since 200 million hectares of land could be used for the expansion of the energy plantations without competing with the protection of eco-systems or food production (Ministério da Agricultura, Pecuária e Abastecimento 2005, 44). In 2009 the Agro-ecological zoning for sugarcane was published by EMBRAPA Solos with data and maps containing information about the areas that due to climatic, pedological and edaphoclimatic criteria are suitable for the expansion of sugarcane plantations. But the zoning does not propose any political measures to control and to limit the concentration of sugarcane in certain areas either but rather provides the technical basis for the formulation of public policies on land use (EMBRAPA Solos 2009). With the implementation of the zoning, the financing of sugarcane plantations in areas of the the Amazon, the Pantanal and the river basin of the Alto Paraguai was forbidden (Presidência da República 2009a). But one major shortcoming is that the occupation in the Cerrado, which represents the main agricultural frontier in Brazil, where the most suitable land and cropland are located and available at lower prices compared to the South and the Southeast, is not restricted in the zoning (Instituto de Estudos do Comércio e Negociações Internacionais 2011).

With regard to the demand of the ethanol producers to change the legislation and to allow the producers to commercialise the ethanol directly and not via the distribution companies, there is no official position but some support within the *MAPA* for this demand [95] (Strapasson 2007). In general, the *MAPA* tends to adopt the positions of the ethanol producers and supports further expansion of sugarcane cul-

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Departamento Nacional de Combustíveis), in 1993 to the President that could change it through a decree or law and in 2001, finally, to the *CIMA* (Presidência da República 1993).

[93] The term "Agroenergy" instead of "Bioenergy" was chosen deliberately in order to stress the fact that the raw-materials for the production of biofuels, biomass or biogas all result from agricultural activities: "Abroad it is called bioenergy, but we think it is important to call it agroenergy because the agricultural part is the most difficult part, you need to move something, [...] in the case of alcohol it is more difficult to convince the farmer to plant sugarcane, it is difficult to balance supply and demand in a healthy way."

[94] "When [the regulative competence for] the alcohol came back to the Ministry of Agriculture, Livestock and Food Supply (*MAPA*), there was a change in the management of the ministry with the new minister Roberto Rodrigues. At this period there was the idea to launch the Biodiesel Programme, so the ministry was restructured for dealing with these subjects within the context called "Agroenergy", in order to enhance the range and at the same time limit the activities because there exists the *MME* that does other things. And Agroenergy is not only alcohol and biodiesel, but also residues and energy forests. From then on, this plan was used to have a directive to show what the ministry does within this area in general."

[95] "The ethanol plants regulate the supply of anhydrous and hydrated ethanol according to the prices. They sell to the distribution companies; this is made for control reasons. For a long time the plants are asking to commercialise the ethanol directly, but this depends upon a change in legislation. I am personally in favour of this change, but the ministry does not have an official opinion. [...] But why the ethanol plants do not hold distribution companies? Because in Brazil, a distribution company cannot sell anything to other distribution companies and because they would have to distribute also gasoline and diesel fuel, but the distribution market is very difficult."

tivation and ethanol fuel production[96] (Ministério da Agricultura, Pecuária e Abastecimento 2005, 44). Thus, it can be considered as a broker of these interests and an important member of the “Ethanol Expansion Coalition”.

### 5.1.2.2. Ministério do Desenvolvimento, Indústria e Comércio Exterior (MDIC)

During *PROALCOOL*, the then called *Ministério de Indústria e Comércio* (MIC - Ministry of Industry and Commerce) decided upon the share of ethanol in *Gasolina C* and an entire directorate was dedicated to plan and control sugar and ethanol production in Brazil. Nowadays, there is only one person working with biofuels in the *Coordenação-Geral de Agronegócios* (Department for Agribusiness), subjected to the *Secretaria de Desenvolvimento de Produção* (Secretary of Production Development) of the now called *Ministério do Desenvolvimento, Indústria e Comércio Exterior* (*MDIC* - Ministry of Development, Industry and External Trade) (Glehn Nobre 2007). Since the competence to decide upon the ethanol share was transferred to the *CIMA* which is presided by the *MAPA*, the *MDIC* has no important competences for regulating biofuels policies anymore. But with the national development bank *BNDES* and the *Instituto Nacional de Metrologia, Normalização e Qualidade Industrial* (*INMETRO* - National Institute for Metrology, Standardization and Industrial Quality), there are two important executive institutions in the biofuel sector subordinated to the ministry. Already in 2003, the *BNDES* realised a workshop in order to discuss the growing opportunities of ethanol production and exportation (Cunha da Costa 2006). It increased the financing of the ethanol sector via *BNDES Automático,* and the *MDIC* justified this by stressing the importance of the ethanol industry as “a vector of [economic and social] development”[97] (Banco Nacional de Desenvolvimento Econômico e Social 2007). As already described in chapter 3.1.7.1, the *BNDES* has become the most important source of financing for the ethanol sector in recent years[98] (Antonio de Pádua Rodrigues 2007). The bank is also responsible for the *Programa de Financiamento para estocagem de álcool combustível com garantia em produto* (Programme for the financing of the ethanol storage) which was introduced by the *CMN* in April 2009 as a support measure for the agricultural sector during the economic crisis and the lack of financing (Banco Central do Brasil 2009).

Since the *MDIC* is also responsible for promoting external trade it has also undertaken some activities in this area. According to the *MDIC*, international trade of ethanol is still limited due to the lack of standardisation and import duties in interesting markets for Brazil[99] (Glehn Nobre 2007). Due to these reflections, the *INMETRO* participated on the Tripartite Task Force Brazil, EU and USA on internationally compatible biofuel standards. Via the *Agência Brasileira de Promoção de Exportações e Investimentos* (*APEX–Brasil*, Brazilian Agency for Export and Investment Promotion) which is subordinated to the *MDIC*, the ministry also promotes exports of ethanol production technology into other potential exporting countries.

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[96] “The ministry wants to expand the cultivation of sugarcane to Western Bahia, Tocantins, Maranhão, to the Northwest. We want to stimulate these poor regions where sugarcane is not cultivated traditionally.”

[97] “Considering the renewable energies as a vector for development, Brazil has to exploit the opportunities which arise from the association of the natural disposal with resources and the territorial extension of the country, the technological progress and its potential environmental benefits from ethanol production. Few countries in the world, like Brazil, have the capacity not only to promote a more sustainable development, but also to use this path of sustainability as a mean for economic and social development” (own translation from Portuguese).

[98] “The BNDES is the largest sponsor in the sugar and ethanol sector today because of financing the new production units. There exist various sources for financing, the BNDES, the external funds, initial public offerings at the stock market, sales of the own production, regional funds. But the largest sponsor is the BNDES.”

[99] “I do not know how this idea to make ethanol a commodity came up for the first time. The first time I heard it was inside the ministry [MDIC] and the USA already bought this idea. Actually it does not make any sense because you try to diversify your product, but you need to standardise your product to enhance your supply. Brazil wants to disseminate the technology in order to export more; it needs to break the resistance of the importing countries.”

Thus, even though the *MDIC* itself does not have any important regulative competences, due to its subordinated institutions it can be considered an important part of the “Ethanol Expansion Coalition” by disseminating the production and use of ethanol in Brazil via granting loans for investments and by contributing to the standardisation of ethanol and the transfer of the production technology in order to increase international trade.

### 5.1.2.3. Congresso Nacional

When analysing actors from the Brazilian legislative, the question arises how to build groups of actors for the analytical assessment. The low ideological coherence of the Brazilian political parties makes it difficult to consider parties as a coherent group of actors when analysing policies (Cintra and Lacombe 2007). The deputies and senators often create *frentes parlamentares*, alliances across various parties between parliamentarians interested in promoting one or several specific issues. In February 2007, the *Frente Parlamentar Ambientalista* (Parliamentary Alliance of Environmentalists) with biofuels as an issue was created, assembling 290 of the 513 federal deputies and 13 of the 81 senators in 2010 (Frente Parlamentar Ambientalista 2010). Due to the large number of deputies and senators, the heterogeneity of the group and the overlapping memberships, the impact of these alliances on the voting behaviour of the parliamentarians is unclear, and this is why this alliance itself will not be analysed as an actor. Rather, the majority vote of the *Congresso Nacional* will help to identify the policy core of the congress as a single actor.

Within the ethanol policy sector, the congress can be seen as part of the “Ethanol Expansion Coalition”. This interpretation is based on the analysis of the conflict between the federal government and the national congress about the changes of the taxation of hydrated ethanol that were introduced with the provisory measure N° 413 (2008) (Câmara dos Deputados 2008). The federal deputies issued 93 amendments[100] to the provisory measure and even some deputies from the governmental basis rejected the concentration of the taxation within the alcohol producers proposed by the provisory measure (Câmara dos Deputados 2009). Only after a reunion of a state-secretary from the ministry of finance, a secretary form the treasury, a representative of *SINDICOM*, a representative of *UNICA* and the rapporteur of the chamber of deputies, a compromise was found and the provisory measure was converted into Law 11,727 with some important changes claimed successfully by the deputies (Valor Econômico 2008). However, some measures with the aim to enforce fiscal regulation of the sector like the installation of the flow measurement devices at the ethanol plants could not be obstructed by the congress. Actually, this regulation already had been included within a parliamentary bill presented at the *Comissão de Minas e Energia* (Commission for Mining and Energy) of the *Câmara dos Deputados* (Chamber of the Deputies), but had been objected by the members of this commission (Comissão de Minas e Energia 2007). This parliamentary bill is an example that there are also some deputies advocating a stricter regulation of the ethanol sector. The bill proposed an extension of the control of the regulatory agency *ANP* over the production, trade, storage and resale of ethanol fuel, but this bill was not voted by the congress until 01/2010 (Santiago 2007). Thus, the majority of the *Congresso Nacional* can be considered part of the “Ethanol Expansion Coalition” because it defended the interests of the alcohol producers against the demands of the association of the distribution companies and the federal treasury and successfully obstructed some regulations proposed initially by the provisory measure N° 413/2008.

[100] 37 of these amendments came from 11 deputies who had received 1 million BRL of donations from sugar and ethanol producers for their campaigns (Sardinha, Lambranho and Militão 2008).

### 5.1.2.4. Presidência da República Federativa do Brasil e Casa Civil

Formally, the presidency is not represented in decision forums such as the *CIMA* for instance and there are few statements of the 35th Brazilian president Luiz Inácio Lula da Silva (2003-2010) about national ethanol policies. However, he tried to promote ethanol internationally as an alternative fuel in order to facilitate access to important markets for Brazilian ethanol by praising ethanol from sugarcane as a clean, renewable and socially and economically sustainable source of energy[101], defending it against international criticism[102] and stressing the necessity to expand ethanol production and to transform it into a commodity in order to enlarge the export market for Brazil[103] (Luiz Inácio Lula da Silva 2007a; Luiz Inácio Lula da Silva 2007b). During the term in office of Dilma Rousseff as chief of the *Casa Civil* between 2005 and 2010, the presidency started to coordinate the discussions within the government about ethanol policies and thus also played an important role in the national biofuel policy arena (Strapasson 2007). At the same time President Luiz Inácio Lula da Silva also requested a study from *BNDES* and the *Centro de Gestão e Estudos Estratégicos* (*CGEE* – Center for Strategic Studies and Management) on the Brazilian ethanol experience to share the lessons learned with other countries and thus also showed increasing international activities (Banco Nacional de Desenvolvimento Econômico e Social and Centro de Gestão e Estudos Estratégicos 2008). Since Dilma Rousseff had been the Minister of Mining and Energy from 2003 to 2005 and thus had played an important role when implementing the biodiesel programme, the attempt to enhance political coordination in the biofuels sector by the presidency can be explained by the personal background of the chief of the *Casa Civil*[104] at that time (Glehn Nobre 2007). The decision-making process in the case of the change of the ethanol share in gasoline is exemplary for the more active role of the presidency within the ethanol policies. Although this decision is formally taken by the *CIMA*, the increase from 20% to 23% in November 2006 was taken after a reunion of Dilma Rousseff with the Minister of Finance (Guido Mantega), the Minister of Mining and Energy (Silas Rondeau) and the Minister of Agriculture (Luiz Carlos Guedes Pinto) (Eliane Oliveira 2006). Thus, while at the international level the president is promoting ethanol fuel, at the national level the *Casa Civil* started to play a more active role for the expansion of ethanol. Although the *Casa Civil* may play the role of a policy broker in ethanol policies sometimes, the president and the presidency can be considered part of the "Ethanol Expansion Coalition".

### 5.1.2.5. União da Indústria de Cana-de-Açúcar (UNICA)

Since 1997, more than 100 ethanol and sugar plants which together produce 50% of the ethanol production in Brazil and more than 80% of the ethanol production in the state of São Paulo are associated

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101 "Brazil has insisted on the tremendous potential of biofuels. They are decisive in the fight against global warming, and they can play an important role in the economic and social development of the poorest countries. Biofuels generate income and jobs, especially in rural areas, while producing clean, renewable energy."

102 "Since the 1970s, when we launched our ethanol program, the per-hectare yields of ethanol have more than doubled. Also, since 1990, our grain output grew by 142%, with an expansion of only 24% in the cultivated area. Our grain production has therefore grown due to spectacular gains in yields. There is thus no basis for statements that the expansion of ethanol production comes at the expense of food production. There are other critics who raise the senseless argument that Brazil's sugarcane plantations are invading the Amazon. [...] The northern region, which includes almost the entirety of Brazil's Amazon rainforest, has only 21,000 hectares planted with sugarcane, that is, only 0.3% of all of Brazil's sugarcane plantations. This means that 99.7% of the sugarcane is at least 2,000 kilometers from the Amazon rainforest."

103 "With regard to alcohol becoming a commodity, I think it is an irreversible question. [...] And we need to have more responsibility because we do not only have to offer alcohol but to guaruantee the supply of the Brazilian market and the international market. Because of this we need to plant much more cane, you need to dynamise the alcohol culture to other countries."

104 "It was already problematic to have so many ministries with diluted competences, but none of them managed to prevail over the others. Today it is the *Casa Civil* which leads the game. This has to do with Dilma Rousseff, she already worked with it before, it is the logic of the occupier, not of the ministerial structure. It is good because it [the *Casa Civil*] has power over the other ministries. But it is one more actor, even the Ministry of Foreign Relations created a department, there comes the time when the government needs to reorganise."

in the *União da Indústria de Cana-de-Açúcar* (*UNICA* - Union of the Sugarcane Industry) (União da Indústria de Cana-de-Açúcar 2010b). It represents the interests of the ethanol and sugar sector within the discussion forums of the government, like the *Conselho Interministerial do Açúcar e do Álcool* (*CIMA* - Interdepartmental Council for Sugar and Alcohol) and the *Câmara Setorial de Açúcar e Álcool* (Sector Chamber for Alcohol and Sugar). But in the perspective of the association, discussions in these forums are restricted to everyday problems while there is a lack of long-term policies and strategic planning for the ethanol sector[105] (Antonio de Pádua Rodrigues 2007). Based on this evaluation, *UNICA* successfully created an agenda with the *Casa Civil* and the Minister Dilma Rousseff, where mid- and long-term challenges shall be discussed in several work groups[106] (Antonio de Pádua Rodrigues 2007). According to *UNICA*, there is no need for "interventionist policies" like in the past, since it is very confident about ethanol being competitive towards gasoline and that the market will regulate demand and supply of ethanol fuel[107] (Antonio de Pádua Rodrigues 2007). The few support policies in the ethanol sector nowadays are often compared to the times of *PROÁLCOOL* in public discussions and brochures in order to stress the high competitiveness of the sector and the little demand for public financial support nowadays (União da Indústria de Cana-de-Açúcar 2007). With regard to national taxation policies, the discussions about the provisory measure N° 413 (2008) illustrate the position and influence of *UNICA*. Together with other associations, *UNICA* was lobbying heavily against passing the tax burden to the alcohol producers and asked for a rejection of the provisory measure. The sector feared the quasi-monopolistic bargaining power of the distribution companies and that the 200 groups selling the ethanol fuel to the distribution companies would not be able to pass the higher tax burden completely to the latter ones[108] (Jank 2008). Thus, *UNICA* and other associations of the sector successfully mobilised a huge number of federal deputies which changed the regulations of the provisory measure when transforming it into Law 11.727.

*UNICA* has also a strong international agenda and is promoting ethanol as an international commodity in order to increase Brazilian exports (Jank 2010). Confronted with growing national and international concerns about the emissions released through sugarcane burning before harvest, *UNICA* signed an agreement with the state government of São Paulo in June 2007 in order to eliminate gradually sugarcane burning in existing cultivation areas[109] (Governo do Estado de São Paulo and União da Indústria de Cana-de-Açúcar 2007). The agricultural and industrial producers receive a certificate when they comply with the provisions of the agreement. Already before signing the agreement, *UNICA* pretended to create a national certification scheme for the ethanol production; an idea that is being realised under the responsibility of *INMETRO* (Instituto Nacional de Metrologia, Normalização e Qualidade Industrial 2008). Thus, *UNICA* is an important actor of the "Ethanol Expansion Coalition" in Brazil.

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[105] "Brazil still lacks a definition on a higher level, a policy of regulation, not of intervention. It lacks a definition of the role of the ethanol fuel in the energy matrix. All this is a policy far away from the creation of a forum where you want to discuss everyday policy. [...] What you need is strategic planning, actions from the government. You define a roadmap until 2020, 2030, what is the scenario for the future, what do you need to invest, what is the expectation, this is what UNICA needs to do."
[106] "And we created an agenda with the *Casa Civil*, with Dilma, where the question is not whether we add 22% or 25% ethanol. We have to resolve the question of the unemployed sugarcane workers after the mechanisation of the harvest, the qualification of manpower in expansion regions, [...] the logistical question of exporting alcohol, [...], the ecological question [...]."
[107] "In the case of the hydrous alcohol, it is a competing product of gasoline. Who will regulate the market is the flexible-fuel vehicle."
[108] This concern was questioned by SINDICOM in the public consultation, since more than 50% of the ethanol is purchased via contracts which are indexed to the "ESALQ price" which does not include taxes which are added automatically to the contract value (Vaz 2008).
[109] Ethanol, sugar and sugarcane producers joining this agreement commit themselves to harvest 70% of their sugarcane without burning in 2010 and 100% in 2014 in areas where mechanisation is feasible and 30% in 2010 and 100% in 2017 where it is not. In March 2008, 85% of the sugar and ethanol plants and the organisations of the sugarcane planters had signed this agreement (Coplana 2008). This voluntary agreement goes beyond state Law 11,241 (19/09/2002) that decrees that 50% (2010) and 100% (2021) of the sugarcane should be harvested without burning in areas where mechanisation is feasible respectively 10% (2010) and 100% (2031) where it is not.

#### 5.1.2.6. Dedini S/A Indústrias de Base

The Brazilian capital goods manufacturer Dedini located in Piracicaba, São Paulo, is the most important capital goods manufacturer in the biofuels sector representing the entire industry in the sectoral chambers of the *MAPA* (Olivério 2007). Between 2004 and 2007, Dedini's turnover more than tripled from 450 million BRL to 1.8 billion BRL, due to increasing sales of sugar and ethanol plants, which account for up to 50% of the enterprise's total turnover. Due to the economic crisis, turnover stagnated at about 2 billion BRL in 2008 and 2009 (Rosenilde Gomes Ferreira 2009). Because of the major importance of ethanol and sugar plants within Dedini's portfolio, the company requested several measures for the promotion of ethanol production and consumption, including the development of heavy-duty engines using ethanol; the promotion of the use of flexible-fuel vehicles in Brazil and abroad and the creation of specific financing lines for the export of ethanol plants and projects with advanced co-generation technologies during a *BNDES* workshop in 2003 (Olivério 2003). Dedini closely cooperates with associations of the sugar and ethanol sector such as *UNICA*, *SINDACÚCAR* (Syndicate of the Sugar and Alcohol Industry in the State of Pernambuco), *ORPLANA* (Organisation of the Cane Growers of the Centre-South Region of Brazil ) and *COPLACANA* (Cooperative of the Cane Growers of the State of São Paulo) and advocates the idea of bioenergy in national and international forums at a national and international context. The company even participates in official missions abroad promoting the production and use of ethanol and receives foreign delegations in Brazil on behalf of the federal government (Olivério 2007). Thus, the strong position of Dedini within the capital goods sector for ethanol, the intensive exchange with the Brazilian ethanol sector and the fact that the government relies on Dedini when promoting ethanol production abroad are indicators that Dedini is sharing many beliefs with other actors from the "Ethanol Expansion Coalition", although public statements with regard to national ethanol policies are rare.

### 5.1.3. The "Ethanol Control Intensification Coalition"

#### 5.1.3.1. Ministério de Minas e Energia (MME) e Agência Nacional do Petróleo, Gás Natural e Biocombustíveis (ANP)

The *Ministério de Minas e Energia* (*MME*) developed some activities in the past years, but it does not have any important executive competences in the ethanol sector. The *Conselho Nacional de Política Energética* (*CNPE* – National Council for the Energy Policy) which is linked to the *MME* has the authority to establish directives for the use of ethanol fuel, but it did not issue any resolutions lately. The important competence to establish the ethanol share in the gasohol is executed by the *Conselho Interministerial do Açúcar e do Álcool* (*CIME*) in which the *MME* participates but which is presided by the *MAPA*. Thus, the main preoccupation of the *MME* is the quality of the ethanol fuel and this is why it can be considered part of the "Ethanol Control Intensification Coalition". Since the compliance of ethanol fuel with Brazilian quality standards is controlled by the regulatory agency *ANP*, which is linked to the *MME*, it is important to analyse this actor as well.

The *Agência Nacional do Petróleo, Gás Natural e Biocombustíveis* (*ANP* - National Agency for Petroleum, Natural Gas and Biofuels) was established in 1997 by the Petroleum Law as an autarchic regulatory agency linked to the *MME* (Presidência da República 1997a). Thus, *ANP* is subjected to the energy policies formulated by the ministry, respective the *CNPE* or other policy-formulating actors (Queiroz Pinto Jr. 2002). Competences of *ANP* for ethanol fuel are limited to distribution and commercialisation activities, but do not include the production of the ethanol, which has to be authorised by the *MAPA*. In 2005, *ANP* introduced the mandatory addition of a colorant to the anhydrous ethanol in order to prevent distribution companies from adding water to the anhydrous ethanol and selling it as hydrous ethanol, thus benefiting from different forms of taxation (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2005). Large distribution companies had claimed for a more comprehensive supervision of the sector by *ANP* after increasing production and consumption of ethanol and increasing adulteration of ethanol fuel (Bakos 2006). In 2006, *ANP* signed an agreement with the *MAPA* in which they declared to exchange monthly data about ethanol production and commercialisation in order to enhance supervision of the sector (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis and Ministério da Agricultura, Pecuária e Abastecimento 2006). Due to these extended control activities, adulteration indices of hydrated ethanol decreased from 9.6% in 2003 to 2.3% in 2008 (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2009b). The consumers benefit from the compliance of the hydrated ethanol with the specifications, although in public discussions about the adulteration of ethanol, the successful prevention of tax evasion is often highlighted and not the improvement in quality and consumer protection (Lorenna Rodrigues 2007).

#### 5.1.3.2. Sindicato Nacional das Empresas Distribuidoras de Combustíveis e de Lubrificantes (SINDICOM)

The *Sindicato Nacional das Empresas Distribuidoras de Combustíveis e de Lubrificantes* (*SINDICOM* - National Association of the Fuel and Lubricant Distribution Companies) assembles the large distribution companies BR-Petrobras, Ipiranga, Shell and others which together hold 77% of the total fuel market in Brazil (Sindicato Nacional das Empresas Distribuidoras de Combustíveis e de Lubrificantes 2010c). In the hydrated ethanol market, market share of these companies only summed up to 45-55% in the last years and for 2007, *SINDICOM* calculated that for 15% of the official sales of 9.3 billion litres of hydrated ethanol, taxes were not paid entirely and that 1 billion litres were commercialised additionally without even being declared resulting in tax evasion of roughly 1 billion BRL (Sindicato Nacional das Empresas Distribuidoras de Combustíveis e de Lubrificantes 2008a). Because of this, the association claimed for a concentration of the taxation within the producers, the installation of flow measurement devices at the plants connected to the Federal Treasury, the implantation of an electronic receipt for the commercialisation of ethanol, a harmonisation of the *ICMS* rates in the states and the extension of the control of the regulatory agency *ANP* over the production of ethanol fuel. Since *SINDICOM* alleged that no illegal practices were used by its own members, the claimed measures were necessary to re-establish the conditions for a fair and transparent competition within the sector which would also result in stable and low fuel prices for the consumers according to *SINDICOM*[110] (Reuters 2008). The concentration of the taxation within the producers and the installation of flow measurement devices at the plants were realised with the provisory measure N° 413 (2008), but in the law that transformed the provisory measure, the fiscal responsibility was split between the producers and the distribution companies. The electronic receipt was introduced in April 2008 for the commercialisation of ethanol (Folha Online 2008). Thus, *SINDICOM* successfully placed the problem of tax evasion in the fuel distribution sector on the political agenda in the last years and important demands were met by the federal government. The changes in the legislation and enforced control activities of *ANP* resulted in slightly growing shares of the *SINDICOM* members of hydrated ethanol sales[111] (Sindicato Nacional das Empresas Distribuidoras de Com-

[110] "Every time there was a cleaning in the fuel sector, the consequence was a more competitive environment [...] More efficient (comercialisation) mechanisms signify more (price) stability" (Reuters 2008).
[111] In 2008 and 2009, share of *SINDICOM* on total sales of hydrated ethanol was about 60%, while in the previous years and especially prior to 2004, this share rarely surpassed 50%.

bustíveis e de Lubrificantes 2010b). Thus, *SINDICOM* can be considered part of the "Ethanol Control Intensification Coalition".

### 5.1.3.3. Petrobras (Petróleo Brasileiro S.A.)

Petrobras[112] (Petróleo Brasileiro S.A.) is a multinational petroleum and derivates company and Brazil's largest company with 52,000 employees and with a net turnover of 213 billion BRL (126 billion USD) and a net profit of 35 billion BRL (21 billion USD) in 2010 (Petrobras - Petróleo Brasileiro S.A. 2011). It is a joint stock company, but since 55.6% of the common shares (31/07/2010) are held by the Brazilian federal government, political influence on company decisions is very frequent. Within the ethanol sector, Petrobras' main activities are the distribution and the transport of ethanol within the domestic market. In the past years, Petrobras began to invest in ethanol production and in logistics for ethanol export. The increase of ethanol production and exports is one main goal of the federal government with President Lula campaigning for the use of ethanol as an alternative to fossil fuels worldwide. Therefore, the ethanol investments by Petrobras follow the political agenda of the government and are part of the *Programa de Aceleração do Crescimento* (*PAC* – Programme for the Acceleration of Growth). Despite the uncertainties about the real development of ethanol production and export within the next years, the possible signing of long-term supply contracts with import countries may also guarantee interesting business opportunities for ethanol producers and exporters by reducing the transport costs significantly. However, Petrobras' efforts to increase ethanol exports could also be interpreted as a way to reduce ethanol supply for the domestic market and to stabilise ethanol prices and indirectly gasoline prices. When international crude oil and gasoline prices soared in 2007/08, Petrobras was forced to raise gasoline prices for the domestic market by 10% in May 2008, while ethanol prices remained constant due to increasing ethanol production. The federal government reduced the fuel excise tax on gasoline from 0.28 BRL/litre to 0.18 BRL/litre in order to improve competitiveness of gasoline against ethanol fuel (see chapter 3.1.7.3.). Due to the oversupply with fuel for passenger cars in Brazil and the volatility of the fuel demand since FFV introduction, Petrobras has to export gasoline to lower prices than it would obtain at the domestic market when ethanol prices are more competitive (Carla de Souza e Silva 2005). Since the market share of Petrobras in the gasoline market is higher than in the ethanol market, the president of Petrobras' distribution company BR Distribuidora José Eduardo Dutra criticised the "distortions" in the ethanol market such as the tax evasion and the differentiated taxation, which reduce the price of ethanol fuel[113] (Kelly Lima 2008). Consequently, Petrobras supported the regulations to be introduced by the MP N° 413 (2008) via *SINDICOM* and expected the ethanol prices to increase and thus the market situation to improve for gasoline. Petrobras' case shows that the federal government has two reasons for reducing possibilities for tax evasion in the fuel sector: first of all, the growing fuel market promises increasing tax revenues and second, the state-owned mineral oil company Petrobras is the most important member of *SINDICOM* and thus the major profiteer from the regulations proposed by *SINDICOM* (Folha de São Paulo 2008). This is why Petrobras can be considered part of the "Ethanol Control Intensification Coalition" since this also helps to improve market position of Petrobras as the main gasoline provider.

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[112] The Petrobras holding includes several subsidiaries, of which interviews with representatives from the "Petrobras Distribuidora S/A – BR" - the distribution subsidiary of Petrobras - and "Petrobras Transporte S/A – TRANSPETRO" – the subsidiary operating the infrastructure and logistic network were realised and considered for this study. In July 2008, after field research, a new subsidiary called "Petrobras Biocombustível" was founded in order to deal with all projects related to the production of ethanol and biodiesel.

[113] "The alcohol does not pay *CIDE* like the gasoline and has a differentiated taxation for the other taxes. Since the government does not signalise that this will change soon, what we have in the country is not a flexible-fuel but a policy flexible-tax."

### 5.1.3.4. Associação Nacional dos Fabricantes de Veículos Automotores (ANFAVEA)

The *Associação Nacional dos Fabricantes de Veículos Automotores (ANFAVEA – National* (*ANFAVEA* – National Association of the Car Manufacturers) congregates the most important multinational automotive companies producing in Brazil[114]. *ANFAVEA* considers ethanol primarily as an important energy carrier that competes with gasoline. When the first flexible-fuel technology was introduced into the market in 2003, flexible-fuel vehicles performed much better with gasoline than with ethanol. Only when the fast growing sales of flexible-fuel vehicles exceeded expectations, the manufacturers decided to offer FFV with higher compression rates and a better performance using ethanol than gasoline[115] (Joseph Jr. 2007). However, with the current flexible-fuel technology in Brazil, there is still a trade-off between the liberty to choose the fuel by the consumer and the performance of the engine: the compression rate is not completely optimised for ethanol which leads to incomplete combustion and emissions higher than could be obtained with dedicated engine parameters[116] (Joseph Jr. 2007; O Estado de São Paulo 2009). But emission standards are not as restrictive as in the US or the EU, and that is why in general, pressure on car manufacturers to comply with emission regulations is lower and there is also few public concern about fuel efficiency. This may explain the support for FFV and ethanol as a fuel by the Brazilian automotive industry. On the international agenda, *ANFAVEA* defends the utilisation of ethanol as a fuel against international criticism (Dal Poggetto 2008). This is also due to the expectation to export the FFV technology to other countries, although there are two important limitations: First of all, the flexible-fuel technology probably will be introduced commercially only in those countries that have the capacity to produce or import large amounts of ethanol. Second, the automotive manufacturers producing FFV in Brazil are part of multinational enterprises that probably will produce FFV for other markets in their factories in the respective countries[117] (Joseph Jr. 2007). Thus, *ANFAVEA's* view is quite pragmatic: ethanol is considered an important fuel in Brazil and some benefits are highlighted. But more important than the intrinsic qualities of ethanol is the fact that the importance of ethanol fuel created the opportunity for the introduction of an innovative technology (FFV) which also promotes car sales in Brazil in general. Thus, for *ANFAVEA* fuel quality is a very important issue since problems with cars may be also caused by low quality fuels and this is why the association can be considered part of the "Ethanol Control Intensification Coalition".

### 5.1.4. Conclusion

Table 37 – Comparative overview on advocacy coalitions in the ethanol policy arena

[114] Members of ANFAVEA are: AGCO do Brasil, Agrale, Caterpillar Brasil, CNH Latin America, Mercedes-Benz do Brasil, Fiat, Ford Motor Company Brasil, General Motors do Brasil, Honda, Hyundai, International, Iveco, John Deere Brasil, Karmann-Ghia do Brasil, Komatsu do Brasil, Mitsubishi, Nissan do Brasil, Peugeot Citroën do Brasil, Renault do Brasil, Scania, Toyota do Brasil, Valtra do Brasil, Volkswagen do Brasil, Volvo do Brasil.

[115] "There was a great anxiety during the launch of the FFV what would be the response of the consumers. [...] Thus, there was the concern to give exactly the same performance with the two fuels even though this would result in a huge difference of the consumption with one or the other fuel, the feeling should be the same. And because of this, the vehicles received a compression rate similar to gasoline. This is what we call the first generation flex."

[116] "The better compression rate [of the ethanol] is not fully utilised in the FFV because the engine also burns gasoline. Even with the anticipation of the heat to the combustion chamber – which helps a lot – we can not use this completely with the FFV. [...] If it were an alcohol engine, you could use a different spectrum of temperatures."

[117] "We are branches of enterprises which have their headquarters in several countries. Even though one country may have interest in buying the flexible-fuel technology from Brazil or launching it in the market, this does not mean that these products would be produced in Brazil and exported to this country. It would have to attend the interests of the multinational enterprise where this technology would be best being produced or where would it be easier to attend the market."

| | "Ethanol Social and Environmental Coalition" | "Ethanol Expansion Coalition" | "Ethanol Control Intensification Coalition" |
|---|---|---|---|
| Analysed actors | MMA,WWF, Conservação International, CPT, MST, etc. | MAPA, MDIC, Congresso Nacional, PR/CC, UNICA, Dedini | MME, ANP, SINDICOM, Petrobras, ANFAVEA |
| Perspective (Belief) | Ethanol as a potential threat to biodiversity and the Agrarian Reform | Ethanol as an important agricultural product | Ethanol as an important energy carrier |
| Policy core | Policies to control/limit the expansion of ethanol production | Support policies for expansion of ethanol production and consumption | Policies to guarantee quality of the ethanol fuel |

The perspective of the "Ethanol Social and Environmental Coalition" (*Ministério do Meio Ambiente, dos Recursos Hídricos e da Amazônia Legal, WWF Brasil*, *Conservação Internacional, Comissão Pastoral da Terra, Movimento dos Trabalhadores sem Terra, Rede Social de Justiça e Direitos Humanos*) emphasises the role of ethanol as a potential threat to biodiversity and the advancement of the Agrarian Reform. However, it should be considered that this coalition is very heteregeneous but not very influential and that the main common ground is the opposition against the unregulated expansion of the ethanol production. But especially the MMA and the environmental NGOs also acknowledge that Brazilian sugarcane ethanol has a high GHG emission reduction potential compared to other biofuels based on corn, wheat, rye or oilseeds. The "Ethanol Expansion Coalition" (*Ministério da Agricultura, Pecuária e Abastecimento*, *Ministério do Desenvolvimento, Indústria e Comércio Exterior*, *Congresso Nacional*, *Presidência da República/Casa Civil*, *UNICA*, and Dedini) emphasises the role of ethanol fuel as an important agricultural product while the "Ethanol Control Intensification Coalition" (*Ministério de Minas e Energia*, *ANP*, *SINDICOM*, Petrobras, *ANFAVEA*) emphasises the role of ethanol as an important energy carrier. The beliefs and the policy demands of these two coalitions are not antagonistic but rather represent different angles of the importance of ethanol fuel in the Brazilian energy system. While for the "Ethanol Expansion Coalition" long-term support policies are necessary to expand ethanol production and consumption, the "Ethanol Control Intensification Coalition" stresses the importance to guarantee the quality of the ethanol fuel.

While the "Ethanol Expansion Coalition" and the "Ethanol Control Intensification Coalition" form strong coalitions that frequently give public statements and take political decisions, the "Ethanol Social and Environmental Coalition" is very heterogeneous and their actors do not comment on every single ethanol issue. This may be also due to limited resources and the fact that the actors have very limited access to the core of the political arena where the decisions are taken. Thus, it is difficult to identifiy the approach of this coalition to the problems put on the political agenda by the other actors. While in the case of the competitiveness and the quality of the ethanol fuel no clear positions could be identified, the positions in the case of the expansion of the international ethanol fuel and market trade range from support of the MMA and the environmental movements to a regulated expansion of ethanol production and export since this helps to mitigate climate change (Shiki 2007; WWF Brasil 2008) to a general opposition of the social movements to ethanol exports since the internationalisation of the agricultural and ethanol production increases the pressure on small farmers and land speculation (Mendonça, Pitta and Xavier 2012).

Table 38 – Positions of selected advocacy coalitions in the ethanol policy arena

| Policy problem | "Ethanol Expansion Coalition" | "Ethanol Control Intensification Coalition" |
|---|---|---|
| Competitiveness of ethanol fuels vs. gasoline | Current federal tax incentives for ethanol fuel and FFV needed | Tax incentives rejected since they encourage fuel adulteration and tax evasion |
| Quality of the ethanol fuel | Stronger control and a shift in taxation rejected, bargaining power of ethanol producers believed to be low | Stronger control of ethanol by ANP needed, shift of taxation to the ethanol producers |
| Expansion of the international ethanol fuel market and trade | International market as an important alternative way to stabilise domestic fuel market and prices | International market as an important alternative way to stabilise domestic fuel market and prices |

Thus, only the approach to three policy problems of the other two – more influent – coalitions will be analysed to show how the positions and the advocating of the coalitions influence the policy output. With regard to the problem "Competitiveness of ethanol fuels vs. gasoline" placed by the "Ethanol Expansion Coalition", this coalition defends the current federal tax incentives for ethanol fuel and FFV and asks for state tax incentives. The "Ethanol Control Intensification Coalition" rejects these tax incentives since they encourage fuel adulteration and tax evasion. Since members of the "Ethanol Expansion Coalition" defend the interests of ethanol producers and suppliers while members of the "Ethanol Control Intensification Coalition" are more heterogeneous and also defend the interests of the gasoline producers and suppliers, the conflict is also about market shares of ethanol and gasoline on domestic fuel market. Due to a consensus on the importance and the beneficial impacts of ethanol production and consumption in Brazil, the tax incentives are not really questioned and no major changes in legislation occur as a policy output. The problem "Quality of the ethanol fuel" is placed by the "Ethanol Control Intensification Coalition" which asks for stronger control of the production and commercialisation of the ethanol fuel by the regulatory agency ANP and a shift of taxation to the ethanol producers in order to avoid adulteration and tax evasion. Stronger control and a shift in taxation to the ethanol producers is rejected by the "Ethanol Expansion Coalition" since bargaining power of the heterogeneous group of ethanol producers against the large distribution companies is believed to be low. The rejection of these changes is partly successful in the case of hydrated ethanol taxation, but some minor changes in control of ethanol commercialisation occur as a policy output. With regard to the problem of the "Expansion of the international ethanol fuel market and trade", actors from both of these coalitions believe that the international market is an important alternative to stabilise domestic fuel market and prices and started to cooperate in the last years in order to improve export infrastructure. Thus, this problem does not divide but rather unifies the actors from both of these coalitions.

## 5.2. Advocacy coalitions within the biodiesel policy arena in Brazil

The biodiesel market in Brazil is a newly established market and several fundamental questions were discussed at the beginning of the biodiesel programme in 2004. Thus, several statements of the main actors could be analysed as well as the legislation that changed several times during the period considered. Like in the case of ethanol, three coalitions could be identified based on the perspectives that differ considerably. The actors of the "Biodiesel Social Development Coalition" represent social groups and believe in biodiesel as a driver for social development and promote policies that should integrate small farmers into the biodiesel value chain. But different from the case of the ethanol policy arena where actors representing social as well as environmental concerns are marginalised and can be assembled in one coalition, environmental concerns are not well represented and cannot be assembled within this coalition, since none of the important environmental actors participated in the biodiesel working group (Kruglianskas 2007; Paulo Gustavo de Prado Pereira 2007). The actors from the "Biodiesel Agribusiness Coalition" represent the large agribusiness and believe in biodiesel as a driver for the development of the oilseeds and more specifically of the soy sector and favour policies that promote biodiesel in general without specific incentives for small farmer production. And the actors from the "Biodiesel Technology and Quality Control Coalition" represent the science and the fuel sector and believe in biodiesel as an important transport fuel but ask for strong regulations and enforcement of regulation regarding fuel quality for example.

## 5.2.1. The "Biodiesel Social Development Coalition"

### 5.2.1.1. Ministério do Desenvolvimento Agrário (MDA)

The *Ministério do Desenvolvimento Agrário* (*MDA* - Ministry of Agrarian Development) is the most distinctive advocate for integrating small farmers into the value chain of the biodiesel production. During the consultations of the biodiesel work group it emphasised that no technological route and no feedstock should be discriminated and that the specifications should regulate only the final product and not the conversion routes. Instead of general fiscal incentives, the ministry argued for governmental incentives for the production, industrialisation and commercialisation of biodiesel (Grupo de Trabalho Interministerial 2003). This demand was almost completely met with the differentiated conditions for loans granted by *BNDES* and the differentiated taxation of biodiesel (see chapter 3.2.2.5). The ministry favoured the option to allow but not to mandate biofuel blend at the beginning of the programme, but was open to discuss a mandatory use later on, since it would need some time to include the small farmers into the value chain of the biodiesel production (Grupo de Trabalho Interministerial 2003). When the *Congresso Nacional* transformed the provisory measure N° 214/2004 into Law N° 11.097 in 2005 and introduced a mandatory blend from January 2008 on, the *MDA* made the *CNPE* issue a resolution that brought forward this mandatory blend for the 1st of January 2006, but restricted it to biodiesel producers holding a social seal in order to promote small farmers (Conselho Nacional de Política Energética 2005). This can be considered a successful example for policy learning through a change in secondary aspects. This is illustrated by a statement of a representative of the *MDA* when acknowledging the mandatory blend as an important contribution of the congress to the biodiesel programme[118] (Arnoldo Campos 2007). The *MDA* had also the idea to continue with the auctions after the start of the mandatory blend in 2008 in order to privilege producers with a social seal. It can be considered an important actor of the "Biodiesel Social Development Coalition" which has the goal to consolidate the participation of the small farmers in the biodiesel production chain[119] (Arnoldo Campos 2007).

[118] "Our option was the voluntary use of the biodiesel. But after the discussion in the Congresso Nacional, we were convinced. B2 should be used, the ministry [the MDA] was favourable to the mandatory use of B2 which was the option strongly preferred within the Congresso Nacional. This was the most important contribution of the Congresso Nacional."

[119] "It is not defined yet whether there will be auctions with B2 becoming mandatory. The MDA defends the continuation of the auctions in order to consolidate the participation of the small farmers, which can weaken without the auctions.[…] The organisation of small farmers by the enterprises is difficult and not yet consolidated. With voluntary B5 there could be auctions for the B3 mandatory share for example. But in 2010, there will not be any auctions definitely."

### 5.2.1.2. Presidência da República Federativa do Brasil e Casa Civil

Since one of the main tasks of the *Casa Civil* is to coordinate the governmental actions, it coordinated the biodiesel work group that was created by President Luiz Inácio Lula da Silva in 2003 and still coordinates the *Comissão Executiva Interministerial* (*CEIB* - Interministerial Executive Commission) that followed the work group when the biodiesel programme was implemented. Despite this coordinative role, the *Casa Civil* and the president are not policy-brokers within the biodiesel policy subsystem but rather actors of the "Biodiesel Social Development Coalition". Already during the first discussions, President Lula stated that different from *PROÁLCOOL*, the biodiesel programme needed to address the social aspects of the biofuel production successfully[120] (Rodrigo Rodrigues 2007). And when he launched the Biodiesel Programme in December 2004, he emphasised the importance of the biodiesel for the Northeast and the social function of the programme (Luiz Inácio Lula da Silva 2004). The president was afraid that the fiscal incentives for the small farmers in the Northeast would be rejected by the agribusiness lobby of the Centre-South in the congress and therefore preferred to issue a provisory measure instead of a law when implementing the biodiesel programme[121] (Rodrigo Rodrigues 2007). But not only the conflict between the president and the opposition in the parliament with regard to the content of the biodiesel policies, also his view of the role of the congress in Brazilian politics are reasons why he can not be considered as a policy broker at all. As already described in chapter 3.2.2, the implementation of the biodiesel programme through a provisory measure illustrates the structural problem of the legislation process in Brazil with non-transparent and time-consuming opinion and coalition forming and the lockdown of the agenda by the executive power. Thus, in his speech in December 2004, the president referred to the difficulty to build a stable basis for the passage of the bills proposed by the government and interpreted the conflict about the biodiesel policies as a game typically played by the parliament[122] (Luiz Inácio Lula da Silva 2004).

During the implementation of the biodiesel programme and the problems related to the production of biodiesel from castor oil, the president realised that the construction of biodiesel plants by the soy business is necessary for the rapid implementation and the credibility of the programme in a first place and that social inclusion would come as a consequence of the implementation of the programme. He stressed the price stabilising function of the biodiesel production for the soy sector and drew a parallel to the sugar and ethanol sector[123] (Luiz Inácio Lula da Silva 2006). But the president was also aware of

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[120] "It [the biodiesel programme] would have to be different from Proálcool. This was Lula's idea; his priority was that the Northeast had an importance in the programme. We always looked at the Proálcool which was a success in effectiveness, but in the social and regional inclusion it is precarious."

[121] "The decision for the provisory measure and not for a parliamentary bill was taken because the President wanted to be in the forefront of the implementation of the biodiesel programme. You issue a provisory measure when there is urgency and relevance, because of the incentives for the Northeast and the small farmers. This could provoke an opposition from the agro-business in the Centre-South, of the soy farmers, the agricultural lobby in the *Congresso Nacional*. And the time it would take in the *Congresso Nacional* with this controversy was unpredictable, it could take two, three years, therefore it was set in motion as a provisory measure."

[122] "All this was voted because of what? Because despite the yelling, the speeches of those against and those in favour, there is a moment when God determines that it shall be the moment of equilibrium. And then, everybody stops, for two minutes, pushes the little button, correctly, and it is voted and then continues with the speech, either in the *Câmara dos Deputados* or the *Senado*."

[123] "And next we will inaugurate a biodiesel plant. [...] We do not have any scale yet but I always say to Blairo [Blairo Maggi, Governor of the state of Mato Grosso]: for the soy producers it will be an extraordinary teaspoon, because soy has its prices controlled by the international market, sometimes it rises and sometimes it declines. At the moment we add soy to the mineral diesel, what will happen? When the price out there will be low, we will produce more biodiesel and when the price out there will be good, we will sell it for a better price. And we will sustain it with this market regulation like we regulate the alcohol and the sugar today. Brazil is the biggest sugar exporter and Brazil is transforming into the biggest producer and exporter of alcohol, too. With soy, the same thing may occur."

the problems created by relying primarily on soyoil and explicitly asked Petrobras Biofuels to implement biodiesel production from oilseeds other than soybeans[124] (Luiz Inácio Lula da Silva 2009).

### 5.2.1.3. Ministério de Minas e Energia (MME)

The *Ministério de Minas e Energia* (MME) is one of the most important actors in the formulation and implementation of the biodiesel policies. In June 2003 the ministry launched the *Programa Biodiesel – O Combustível Verde* (Biodiesel Program – a Green Fuel) and commissioned a study that concluded that biodiesel production using castor oil in the Northeast could be feasible (Leal 2007). Based on this study, the ministry recommended that 50% of the biodiesel produced in Brazil should originate from castor oil processed in the Northeast and proposed subsidies for the feedstock and the biodiesel producers. But the ministry was also concerned about the quality of the biodiesel and did not want to allow the use of B100 since quality problems could compromise the confidence of the consumers and the entire programme (Grupo de Trabalho Interministerial 2003). The *MME* also presides the *CNPE*, which issued the resolutions that established the biodiesel auctions and decided upon the stepwise increase of the mandatory blend. Since the auctions and the mandatory blend are the most important tools for promoting the biodiesel production, the ministry itself can be considered one of the most important actors promoting the production and utilisation of biodiesel and that also emphasises the social development through the biodiesel programme.

### 5.2.1.4. Petrobras (Petróleo Brasileiro S.A.)

In 2008 and 2009, three biodiesel plants of Petrobras located in Candeias/Bahia, Quixadá/Ceará and Montes Claros/Minas Gerais were inaugurated[125] (Agência Brasil 2008; Nielmar de Oliveira and Stênio Ribeiro 2008; Laguardia 2009). Petrobras plans to produce 940 million litres of biodiesel annually in 2012 and to invest 480 million USD in the biodiesel sector between 2009 and 2013 (Palácios 2009). The company had started biodiesel production from castor oil in a pilot project in Guimaré (Northeastern state of Rio Grande do Norte) in 2005/06 when searching for a use of treated waste water from crude oil extraction in the Northeast as irrigation water for non-edible cultures[126] (Mascarenhas 2006). Since 2008, the biodiesel activities are managed by the subsidiary "Petrobras Biocombustível" and since May 2009, the former Minister of Agrarian Development Miguel Rossetto is the manager of that subsidiary. His nomination illustrates the strategy of the government to improve the social performance of the biodiesel programme via the commitment of Petrobras. According to Miguel Rossetto, Petrobras' goal is to work with the regional oilseeds cultivated by small farmers and to increase the participation of feedstock provided by these small farmers[127] (BiodieselBR 2009). Thus, Petrobras' investments in bio-

[124] "We do not have the right to depend on soy [...] because soy is a foodstuff and there are one billion human beings that starve from hunger. [...] We need to research and invest in new oilseeds so that we diversify the biodiesel production. [...] And there, Miguel Rossetto, there is no other thing. This will only happen if you, from Petrobras Biofuels, will assume."

[125] Each plant has an annual production capacity of 57 million litres of biodiesel, together the three biodiesel plants can produce 170 million litres of biodiesel annually.

[126] "Five years ago [2001], we realised a study in order to analyse what could be done with the wastewater coming from the oil extraction.[..] The wastewater with low contamination of crude oil must be treated and then disposed into the ocean via long pipelines in the Northeast, close to Guimaré. So, we searched for more cost-effective alternatives and the irrigation of non-edible and robust cultures like castor beans appeared as an option. But at that time, the use of the castor oil for biodiesel was not yet being discussed."

[127] "We are working with the oilseeds that are part of the culture and the vocation of the semi-arid region. Castor, now sunflowers – a novelty that EMBRAPA is presenting to us with much enthusiasm in several areas of the semi-arid –, macaúba (Acrocomia aculeata), especially in Minas Gerais. And we are enthusiastic with the possibilities of jatropha. We also work to a lesser extent with cottonseed and in some areas with soy, especially in Bahia and Minas Gerais. Our units are all flexible and our duty is obviously to secure a relation with the small farmers, required in the law, progressing towards 30% with a strategy of variable and economically sound supply."

diesel production do not only reflect business interests[128] (Mascarenhas 2006), but also the strategy of the government to utilise Petrobras' financial and logistical resources to promote the social agenda of the biodiesel programme and this is why the company can be considered part of the "Biodiesel Social Development Coalition". The fact that the *MST* only cooperates with Petrobras but with no other biodiesel companies shows that it is believed that the company follows the directives of the federal government and is committed to the social aspects of the biodiesel programme (Mohr 2008). Petrobras played and still plays an important role within the auctions, since biodiesel is first acquired by the subsidiary Petrobras Distribuidora and then resold to other distribution companies. It cannot be excluded that the costs of the biodiesel purchase are not surpassed fully to the consumers, either directly via BR-Petrobras or via other distribution companies purchasing biodiesel and diesel from Petrobras. Thus, this regulation could allow Petrobras to cross-subsidise biodiesel production and distribution and to reduce dividend payout and payment of taxes on profits and royalties, but there is no evidence for such a hypothesis.

### 5.2.1.5. Brasil Ecodiesel

Just before the launch of the biodiesel programme, the company Brasil Ecodiesel had initiated a project in the Semi-Arid of the Northeast in the state of Piauí, in which biodiesel should be produced using castor oil planted by small farmers. The idea to use castor oil produced by small farmers in the Northeast was presented during the consultations of the work group for biodiesel and soon adopted by the government as a reference model for the biodiesel programme[129] (Brasil Ecodiesel 2006; Brasil Ecodiesel 2010a). Thus, Brasil Ecodiesel was one of the first enterprises to invest in the biodiesel production and more specifically in the Northeast, although the strategy to establish biodiesel production based on castor beans cultivated by small farmers in remote areas of the Northeast partly failed. After financial problems and difficulties with raw material supply for some units, Brasil Ecodiesel deactivated two plants in the Northeast in December 2009 (Brasil Ecodiesel 2009; Samora 2009). In March 2010, four of Brasil Ecodiesel plants (two of them already deactivated) lost the social seal conceded by the *MDA* because the minimum requirements of raw material supply from small farmers were not fulfilled (Brasil Ecodiesel 2010b; Ministério do Desenvolvimento Agrário 2010c). In 2008, Brasil Ecodiesel started to process Petrobras alleging that Petrobras had not collected biodiesel for several months contracted via the auctions and the dispute revealed the huge logistical challenge when implementing biodiesel projects in areas with an insufficient infrastructure (Agência Estado 2008). But Brasil Ecodiesel is still one of the few companies that invest in biodiesel production with small farmers in the Brazilian North and Northeast and that tries to demonstrate the technical, economic and social feasibility of biodiesel from oilseed production from small farmers, and thus is an important actor of the "Biodiesel Social Development Coalition".

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[128] "The reasons for starting to produce biodiesel were numerous: First of all, it is a market question, Petrobras does not want to lose market share. Second, we have social responsibility, we want to create jobs. We also want an optimisation of the logistic, of the supply with fuels in Brazil, we will stop importing diesel fuel and start to produce fuel locally. And in the energy sector, the government is putting emphasis in the biodiesel programme, this is a huge challenge, a new ground, there will be a lot of learning, it is a directive of the government, but it is also the strategy of the company itself to act as an energy company."

[129] The project was actually presented by the company Enguia Power, an energy company. The owner of Enguia Power, Daniel Birmann, founded Brasil Ecodiesel in 2003 and launched an initial public offering in 2006 in order to raise resources for the construction of further biodiesel plants throughout Brazil. Only 379 million BRL instead of the expected 700 million BRL were raised during the offer. The lower public offers may be due to the fact that Brasil Ecodiesel alerted that the biodiesel sold at the first four auctions probably would not be delivered in time since until 30th of September 2006 only 16 million litres of biodiesel (less than 50% of the biodiesel to be delivered until the end of 2006) had been delivered to Petrobras and REFAP (Brasil Ecodiesel 2006).

#### 5.2.1.6. Confederação Nacional dos Trabalhadores na Agricultura (CONTAG)

The *Confederação Nacional dos Trabalhadores na Agricultura* (*CONTAG* - National Confederation of the Agricultural Workers) was founded in 1963 by the *Movimento Sindical dos Trabalhadores Rurais* (*MSTR* – Union Movement of the Rural Workers) as a national representation of the small landholders, the permanent and seasonal rural wageworkers, the family farmers and the landless (Confederação Nacional dos Trabalhadores na Agricultura 2010). During the 1980s, several other organisations like the *Movimento dos Trabalhadores Rurais Sem Terra* (*MST* - Movement of the Landless Rural Workers) and the *Central Única dos Trabalhadores* (*CUT* – Unified Workers' Central) were founded but due to the principle of unified labour unions in Brazil, *CONTAG* continues to be the representation of the rural workers by law and thus has a privileged status. It participated on the consultations of the biodiesel programme but did not really express any stakes. But in the view of the confederation, the programme is committed to social development and the tax exemption for biodiesel produced from raw material acquired from small farmers is an effective tool for the inclusion of the farmers into the value chain[130] (Rovaris 2007). By requiring the participation of *CONTAG* or any other representation of the rural workers accredited by the *MDA* in the negotiations between the small farmers and the biodiesel enterprises for the social fuel seal, the *MDA* strengthened the role of these organisations and thus achieved the support for the programme by these organisations[131] (Abramovay and Magalhães 2007, 17). Although *CONTAG* criticises that benefits for the biodiesel producers are higher than for the feedstock suppliers, the organisation believes that the expansion of commodities like sugarcane and soybeans promoted by the use of biofuels may stabilise the prices for other agricultural products and thus help to improve the income of the rural workers[132] (Rovaris 2007). Thus, different from other associations of rural workers, *CONTAG's* perspective is in line with market-orientated design of the biodiesel programme and criticism is limited to more practical challenges within the implementation of the programme like the limited access of the small farmers to the funds of *PRONAF* and the lack of certified seeds for the cultivation of castor beans and jatropha curcas (Thuswohl 2007). Already in 2005, *CONTAG* started to sensitise the rural leaderships for the biodiesel programme according to an agreement signed with the *MDA*. The confederation is also receiving funds from the ministry for the employment of biodiesel consultants within the 22 state associations linked to the national confederation (Rovaris 2007). Thus, due to the direct involvement into the social seal and the support for the social inclusion of the small farmers, *CONTAG* can be considered an important actor within the "Biodiesel Social Development Coalition".

#### 5.2.1.7. Congresso Nacional

In June 2002, the first bill (PL 6983/2002) for the introduction of a biodiesel programme was proposed by the deputy Antônio Carlos Mendes Thame (PSDB/SP). This and the second bill (PL 526/2003) presented in March 2003 by the deputy Rubens Otoni (PT/GO) included mandatory blends but did not mention the inclusion of family agriculture into biodiesel production (Mendes Thame 2002; Otoni

[130] "In the discussion about the biodiesel programme, *CONTAG* did participate, but almost without force, without a strong opinion, *CONTAG* was not yet represented in Brasília. The final model adopted by law follows our point of view: a model with the obligation to include the agriculture. The farmers are at least the suppliers of the raw oil of the biodiesel.[...] The reason why we are contacted and included by the national biodiesel industry is not the better condition of the small farmer from the perspective of the production, but rather the tax exemption for the industry."

[131] However, some of the representations of the rural workers do not support the *PNPB* and the use of a social seal. The *Federação dos Trabalhadores na Agricultura Familiar* (*FETRAF* - Federation of the Workers in Family Agriculture) criticises the limited role of the small farmers as suppliers of raw material in the value chain.

[132] "The evaluation of *CONTAG* is that the expansion of the sugarcane will open perspectives for other plants. The sugarcane can regulate the market, right now the remuneration for the agriculture is very low, the sugarcane may increase, and there is space for oilseed crops. To cultivate rice for instance is not feasible in Mato Grosso, but the sugarcane enters and the prices may improve. The migration of soy to the North is one possibility, although there is an environmental dilemma."

2003). Only the third bill (PL 2578/2003) presented in November 2003 by the federal deputy Durval Orlato (PT/SP) emphasised the role that small farmers could play for the implementation of the biodiesel programme (Orlato 2003). After the realisation of a biodiesel exposition in November 2003, the *Conselho de Altos Estudos e Avaliação Tecnológica da Câmara dos Deputados* (Council of Studies and Technological Evaluation of the Chamber of Deputies) composed by deputies from various parties published a study on biodiesel and social inclusion (Holanda 2004). Until March 2010, 30 bills related to the energetic use of biodiesel had been presented in the *Congresso Nacional* and it is difficult to consider the congress as a single actor (Câmara dos Deputados 2010). When transforming the provisory measure N° 214/2004 into Law N° 11.097 (2005), the congress included a mandatory blend for biodiesel within a short time frame and this regulation favoured rather well established producers of soy oil of the Centre-South region than small farmers which still had to be integrated into the biodiesel production chain. But the provisory measure N° 227/2004, that established the differentiated taxation of biodiesel, was transformed by the congress into Law N° 11.116 (2005) without significant changes and thus maintained privileged treatment of small farmers and the semi-arid regions[133] (Rodrigo Rodrigues 2007). Thus, due to this important measure and the several initiatives of the deputies for the promotion of the biodiesel programme, the majority of the *Congresso Nacional* can be considered part of the “Biodiesel Social Development Coalition”.

### 5.2.2. The “Biodiesel Agribusiness Coalition”

#### 5.2.2.1. Ministério da Agricultura, Pecuária e Abastecimento (MAPA)

Despite being responsible for the structuring of the agricultural and industrial biodiesel production chain within the biodiesel programme, the *Ministério da Agricultura, Pecuária e Abastecimento* (*MAPA* - Ministry of Agriculture, Livestock and Food Supply) did not claim any interests during the consultations of the work group in 2003. Only later on with the creation of the *Câmara Setorial de Biodiesel e Oleaginosas* (Sector Chamber for Biodiesel and Oilseed Crops) as a deliberative institution for the ministry assembling a broad range of private and state actors, the ministry tried to open an alternative forum for discussions outside the fora dominated by the *MDA*. The perspective of the *MAPA* on the biodiesel policies differs considerably from that of the rivalling *MDA*. In 2005, the *MAPA* questioned the viability of a project of Brasil Ecodiesel in the interior of the Northeast due to the limited availability of feedstock and more specifically castor oil near the industrial unit[134] and criticised the insufficient fiscal incentives for biodiesel producers in the Centre-South[135] (Ministério da Agricultura, Pecuária e Abastecimento 2005, 50). The *Câmara Setorial de Oleaginosas e Biodiesel* criticised the low taxation of unprocessed soybean

133 “In the case of the tax model, there were intense debates in the congress with the *bancada ruralista* from the South, Southeast and Centre-West region - the richest region with the soy production - opposing to parliamentarians from the North, Northeast - the poorest regions which by the proposal of the government would benefit the most. Thus, there was a regional debate and the question agrobusiness versus small farmer production which maybe never would reach significant amounts. Thus, there was an intense debate, but the thesis of the government to estimulate the regional development and the small farners prevailed.”

134 “This region [the Northeast] […] is characterised by the pioneerism of the biodiesel initiatives. At the moment […] the focus is on castor. This is reflected […] by the plant of Brasil Biodiesel [author’s note: now called Brasil Ecodiesel], localised in the municipality of Floriano, Piauí. The plant of Brasil Biodiesel […] will have the capacity to process 90,000 litre/day. It is a venturous project, especially because of the lack of raw material in the surroundings. The enterprise installed a model settlement in the municipality of Canto do Buriti, which is about 225 km away from the industrial unit. This settlement will be able to produce up to 14,000 tons of mamona per year, which equals 25% of the demand of the industrial unit. The rest must be acquired from small farmers of the region.”

135 “One can draw the conclusion that in the Centre-South region, despite the higher necessity for biodiesel and the higher diversity of alternatives, the environment of uncertainty combined with the insufficiency of the fiscal incentives pose severe difficulties for the utilisation of the installed capacity of the projects underway, what will be reflected in strong difficulties to promote the construction of new ones.”

exports and the higher taxation of soy meal and soy oil exports in Brazil ("perverse taxation that encourages the deindustrialisation of the sector") and claimed an exemption from interstate *ICMS* for soy in order to reduce biodiesel production costs (Ministério da Agricultura, Pecuária e Abastecimento 2006, 371; Câmara Setorial de Oleaginosas e Biodiesel 2006). Although the ministry recognised that other oilseeds may be economically more attractive than soy (Strapasson 2007), it highlighted the expansion of soybean cultivation as a first step to attend the growing domestic and external demand for biodiesel (Ministério da Agricultura, Pecuária e Abastecimento 2006, 371). It stressed the technical limits of the integration of small farmers into the biodiesel production process and believed that the cultivation of new areas beyond the "agricultural frontier" in the Centre-West by large-scale units will be more feasible than the recuperation of semi-arid regions in the Northeast (Vieira 2004, 149). The ministry uses economic feasibility as the main argument to question biodiesel production based on small farmers but at the same time asks for fiscal incentives for the soy and the biodiesel production based on soyoil and thus can be considered part of the "Biodiesel Agribusiness Coalition" that stresses the needs and demands of the large scale oilseed and biodiesel production units, concentrated in the Centre-South region.

#### 5.2.2.2. União Brasileira do Biodiesel (UBRABIO)

The *União Brasileira do Biodiesel* (*UBRABIO* – Brazilian Biodiesel Union) was founded in July 2007 and assembles 27 biodiesel producers and equipment manufacturers, such as Agrenco, Agropalma, Bertin, BSBios, Caramuru, Granol, Brasil Ecodiesel, Naturoil, Dedini and GEA Westfalia Separator (União Brasileira do Biodiesel 2010). The installed and authorised production capacity of these producers amounted to 3.5 billion litres of biodiesel in July 2010, representing 69% of the total production capacity of 5 billion litres of biodiesel (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2011c). Thus, UBRABIO is the most representative biodiesel association in Brazil and this is also recognised by the federal government, which realises frequent meetings with the association (Ministério do Desenvolvimento Agrário 2007; DCI 2007). The first president of the association, Juan Diego Ferrés, is a manager of the Brazilian soy oil and biodiesel enterprise Granol and was president of the biodiesel commission of the *Associação Brasileira das Indústrias de Óleos Vegetais*[136] (*ABIOVE* - Brazilian Association of the Vegetable Oil Industry). He participated on the consultations of the biodiesel work group in 2003 and represented the interests of the soy business. He stressed that the biodiesel programme could be a huge opportunity for the national development, that soy was the only crop with scale for a national programme and that the oil mills could easily be adapted to process other oilseeds than soybeans (Grupo de Trabalho Interministerial 2003, 5). In 2005, Juan Diego Ferrés claimed for a tax exemption for all biodiesel producers and criticised the "model of the government which privileged exclusively the small farmers and the semi-arid regions"[137] (Mian 2005). The claim to extend the tax exemption to biodiesel produced from intensive agriculture was repeated several times by *ABIOVE*, but not met by the government (Brasil Energia 2007). In 2007, Ferrés underlined the importance of the agribusiness and the soy complex for Brazil but criticised that due to the higher import tariffs to manufactured soy products in the USA, EU and China and the tax exemption for exports of unprocessed soy beans in Brazil, the idle capacity of the oil mills increased while the added value of the soy products decreased. Since the bio-

[136] The association was founded in 1981 and assembles 11 enterprises (ADM, Bunge,Cargill, Imcopa, Louis Dreyfus, etc.) which are responsible for 72% of the soy processing in Brazil (Associação Brasileira das Indústrias de Óleos Vegetais 2008).
[137] "However, we do not really believe that the mandatory blend [...] will manage to structure the market in a way that it will transform the country in the biggest biodiesel producer in the world. There must be also a natural economic condition that will lead to a situation where the biodiesel will be produced for less than diesel fuel, and for this it is very important that there is a tax exemption for the infant biodiesel production in the initial years. [...] The government adopted a different model to exclusively benefit the small farmers and the dry regions, with the so called social seal, but this cannot be done at the expense of the adoption of biodiesel as a very important biofuel for the energy matrix."

diesel production represents an interesting market segment in periods of low soy prices for the sector, *UBRABIO* repeatedly asked for higher blends and expected that the mandatory blend would be increased up to B10 until 2015 (Agência Safras 2009). The association that represents the interests of large scale biodiesel production companies can be considered an important actor of the "Biodiesel Agribusiness Coalition".

#### 5.2.2.3. Dedini S/A Indústrias de Base

Dedini participated in the discussions of the biodiesel work group[138] but while the political discussions focused on small-scale biodiesel production, Dedini believed that the programme would need large scale production technology very soon[139] (Olivério 2007). Dedini purchased a licence for the DeSmet Ballestra technology and sold several biodiesel plants with an annual biodiesel production capacity of 50,000 to 300,000 tons (Dedini 2008). An important contribution to the discussions of the biodiesel programme was a detailed study about the estimated production costs of biodiesel in different Brazilian regions that was commissioned by Dedini in 2005[140] (Olivério 2007). The results of the study were contrary to some studies commissioned by the government and questioned the economic feasibility of small scale biodiesel production in the Northeast by using castor oil as a feedstock. Due to Dedini's commercial objectives, the focus of this study was on the economic feasibility of the biodiesel production - and not on the availability of the feedstock or the socioeconomic impact or other aspects that could be equally important. Since Dedini is more focused on large scale agricultural production units and influenced political discussions with the study, it can be considered part of the "Biodiesel Agribusiness Coalition".

### 5.2.3. The "Biodiesel Technology and Quality Control Coalition"

#### 5.2.3.1. Ministério da Ciência e Tecnologia (MCT)

Already in 2002, the *Ministério da Ciência e Tecnologia* (*MCT* - Ministry of Science and Technology) launched the *Programa Brasileiro de Desenvolvimento Tecnológico de Biodiesel* (*PROBIODIESEL* - Brazilian Programme of Technological Development of Biodiesel) with the objective to turn Brazil into a "world leader in biofuels" (Ministério da Ciência e Tecnologia 2002a). Thus, the MCT set biodiesel on the political agenda and prepared the way for the biodiesel programme to be launched. During the consultations of the biodiesel work group in 2003, the ministry advocated the authorisation of the use of B100 and the realisation of motor tests with B100. It believed that technological problems could be solved more rapidly this way and that the results could be useful for blends of diesel and biodiesel (Grupo de Trabalho Interministerial 2003, 28). The ministry financed different research activities within

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138 "At the end of the Cardoso government, it was considered to make a biodiesel programme, but it had no political support. At the beginning of the Lula government, the president himself adopted this subject and started to induce what was called *PNPB*. From then on, we participated in everything, we went to Brasília and there was a work group where we participated."

139 "At the beginning one was thinking in small and distributed plants, focusing on the production of small farmers. But we made an evaluation of the impetus of a strategic market and we saw that at our conclusion, this would be a programme with large dimensions, of a magnitude comparable with *PROALCOOL*. Thus, besides the small plants for small farmers, there would be the need for large scale units, and these would need to have the maximum efficiency, would have to be continuous units completely controlled by integrated software."

140 "It was at the end of 2004 and there was a lot of divergent information about the production costs of biodiesel in Brazil and the availability of the oilseed crops for biodiesel production. One was talking a lot about castor oil, Macaúba [Acrocomia aculeate], palm oil, a lot of things but without having a real data base. [...] We commissioned a study about the availability and the productions costs of biodiesel in the five macro-regions of the country as a support for the political and entrepreneurial decision-making. [...] And we handed this study over to the minister [of Agriculture, Livestock and Food Supply] Roberto Rodrigues in October 2005 when the National Plan for Agroenergy was launched here [in Piracicaba]."

the *Rede Brasileira de Tecnologia de Biodiesel* (Brazilian Biodiesel Technology Network) and signed cooperation agreements with 23 state governments and stimulated the governments to implement state biodiesel programmes (Duarte Filho 2007). Thus, by launching the *PROBIODIESEL* and later on the *Rede Brasileira de Tecnologia de Biodiesel*, the ministry collected and presented the different research activities and illustrated that biodiesel production in Brazil can be realised using different feedstocks and different production systems. The ministry presented important information for other actors that advocated the biodiesel programme in its present form. But from the public calls for the R&D funding, there cannot be drawn any conclusions about the preference of small farmers or agribusiness biodiesel production. Since its focus is on the technological development and the quality aspects of the biodiesel production, it is considered a main actor of the "Biodiesel Technology and Quality Control Coalition".

### 5.2.3.2. Agência Nacional do Petróleo, Gás Natural e Biocombustíveis (ANP)

After the launch of the biodiesel programme, the competences of the *Agência Nacional do Petróleo, Gás Natural e Biocombustíveis* with regard to the biodiesel sector were inserted into the Petroleum Law[141] (Presidência da República 1997a). In resolution N° 41 (24/11/2004), *ANP* determined that biodiesel enterprises would have to present several documents (e.g. tax number, environmental licence, technical report) in order to get an authorisation for biodiesel production (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2004a). Different from the case of the ethanol sector, the control competences of *ANP* embrace the whole biodiesel production and commercialisation chain[142] (Werner 2007) (see chapter 5.1.3.1). During the consultations of the work group in 2003, the agency drew attention to the importance of specifications and mentioned some crucial indicators that would have to be considered in order to ensure the quality of the biodiesel and the protection of the consumer (Grupo de Trabalho Interministerial 2003). But the government did not follow this demand and the first biodiesel standard created in 2004 specified limits for few properties in order to not exclude any oilseeds from biodiesel production. However, with the mandatory use of B2 in 2008, the agency issued a new standard for biodiesel in which most properties were specified following the European and US standard for biodiesel (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2008b). During a public consultation of the draft standard, *ANFAVEA* and *SINDICOM* had asked for some more restrictive limits, but these demands were denied in most cases (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2007c). Although fuel standards were not specified for biodiesel at the beginning of the programme due to concerns about the compliance of biodiesel made from feedstocks from family agriculture, *ANP* implemented relatively strict limits later on and thus can be considered part of the "Biodiesel Technology and Quality Control Coalition".

### 5.2.3.3. Sindicato Nacional das Empresas Distribuidoras de Combustíveis e de Lubrificantes (SINDICOM)

During the consultations of the work group in 2003, *SINDICOM* defended the idea that biodiesel should be taxed like mineral diesel in order to minimise incentives for adulterations like adding a higher bio-

[141] In accordance with Art 8., ANP shall regulate and authorise the activities related to the production, importation, exportation, storage, distribution, resale, and commercialisation of biodiesel, controlling them directly or through agreements with other federal, state or local authorities.
[142] "The *Ministério da Agricultura, Pecuária e Abastecimento* has the competence for the ethanol legislation. In the case of ethanol, *ANP* only deals with the fuel, the standard. An ethanol plant does not need the authorisation from *ANP*. In the case of the biodiesel, *ANP* deals with the production, *ANP* controls it."

diesel percentage[143] (Horn 2007). The association also claimed that the biodiesel should be added to the diesel within the refineries and that taxes for biodiesel would be collected at the refineries enabling the transference of the tax burden to the diesel. Blending biodiesel at the 13 refineries of Petrobras would guarantee the quality of the blend, minimise opportunities for tax evasion, facilitate the logistics and reduce the costs of the biodiesel-diesel blend according to *SINDICOM*[144] (Horn 2007). This demand was not met by the government, but the distribution companies have to prove that they acquired the amount of biodiesel equivalent to the amount of diesel they pretend to purchase at the Brazilian refineries which are completely held by state-owned Petrobras (Sindicato Nacional das Empresas Distribuidoras de Combustíveis e de Lubrificantes 2008b). Main concern of SINDICOM is the quality of the biodiesel that may differ due to the diversity of raw materials and production processes used by the numerous biodiesel producers. To ensure fuel quality, the association cooperates closely with the regulatory agency ANP (Rosas 2007). SINDICOM is supporting the biodiesel programme in general (Gadotti Filho 2007), but overall focus is on the quality of the biodiesel and not on the origin of the raw material and this is why it can be considered part of the “Biodiesel Technology and Quality Control Coalition”.

#### 5.2.3.4. Associação Nacional dos Fabricantes de Veículos Automotores (ANFAVEA)

During the consultations of the work group on biodiesel in 2003, the *Associação Nacional dos Fabricantes de Veículos Automotores* represented the interests of the car manufacturers. The association favoured a cautious introduction of the biodiesel into the Brazilian energy matrix in order to prevent damages on compression ignition engines and emphasised the need for tests with 2% biodiesel blends before permitting the use of B2 in their vehicles (Grupo de Trabalho Interministerial 2003, 3). Confronted with the pressure of the government to guarantee warranty for the use of B2, *ANFAVEA* declared the full support for the biodiesel programme and permitted the use of B2 without any tests in an open letter sent to the president in May 2004[145] (Joseph Jr. 2007). The association continued to stress the necessity of extensive tests before allowing the use of B5 and these tests were realised in the following years within the framework of a national test programme coordinated by the *MCT* and with the participation of the *MME*, the *MDIC*, *ANP*, *BNDES*, the engine and automotive manufacturers and several research institutions. But the automotive manufacturers continued to worry about an anticipation of a B5 mixture without having concluded the tests[146] and complained about the pressure from the government to introduce biodiesel as soon as possible[147] (Joseph Jr. 2007). *ANFAVEA* justifies the cautious approach to

[143] “We think that the taxation of the biodiesel should be the same like for the mineral diesel, because a small difference will create a disequilibrium between the two products. […] Someone can add more biodiesel to the diesel than permitted when it will have less taxes, depending on the price.”

[144] “*SINDICOM* proposed at the beginning of 2003 that the blending with biodiesel should be done directly at the refinery in order to ensure the quality, the correct blending process, the correct percentage. And that the taxes should be levied – and we are still advocating this – at the producer. The legislation now gives the opportunity that the blending can be realised either at the distribution company or the producer. […] But when you transfer it to the distribution companies […] the possibilities of adulteration, of tax evasion increase infinitely.”

[145] “The Brazilian government started to walk into the direction of 5%, but we did not know anything yet about the quality of the biodiesel, there was no standard. Thus, *ANFAVEA* suffered much pressure from the government which asked us to guaruantee warranty for the vehicles using 5%. Thus, we sent a letter to the government stating that we supported the use of B2 without realising any test, and that we would also agree to use B5 provided that a test programme was realised.”

[146] “The great concern is that the government decides from one moment to another, that it allows something that will not work. […] We, the automotive manufacturers, already believe that a decision will be taken even without having realised all tests and we will be asked whether we agree or not. Internally, we discussed a lot what we will do, these are official tests, but obviously many manufacturers have made their own tests, the difficulty is that you never know whether the biodiesel is adequate or not.”

[147] “The biodiesel programme is more a governmental programme, the government has stakes from a social perspective […] it is a time-consuming discussion, we do not manage to meet the deadlines. […] At the same time, there is a lot of pressure from the government that the use of biodiesel will be realised as soon as possible, the government wants to allow B5 in 2010 already.”

biodiesel with the difficulty for the clients to identify low quality fuels as a cause for problems with the performance of their vehicles[148] (Joseph Jr. 2007). Thus, *ANFAVEA* is an important actor of the "Biodiesel Technology and Quality Control Coalition" that is indifferent to the social aspects, but not to the quality aspects of the biodiesel.

### 5.2.4. Conclusion

Within the biodiesel subsystem, three different coalitions could be identified: the "Biodiesel Social Development Coalition", the "Biodiesel Agribusiness Coalition" and the "Biodiesel Technology and Quality Control Coalition".

Table 39 – Comparative overview on advocacy coalitions in the biodiesel policy arena

| | "Biodiesel Social Development Coalition" | "Biodiesel Agribusiness Coalition" | "Biodiesel Technology and Quality Control Coalition" |
|---|---|---|---|
| Analysed actors | MDA, PR/CC, MME, Petrobras, Brasil Ecodiesel, CONTAG, CN | MAPA, UBRABIO, Dedini | MCT, SINDICOM, ANFAVEA, ANP |
| Perspective (Belief) | Biodiesel as driver for social development | Biodiesel as driver for development of oilseeds (soyoil) sector | Biodiesel as an important transport fuel |
| Policy core | Small farmers can provide substantial part of the biodiesel feedstock, integration has to be promoted | Economic feasibility shall decide upon supply and structure of agricultural production and upon biodiesel production | Strong regulations and enforcement of regulations with regard to quality, mandatory blend, etc. is necessary |

The "Biodiesel Social Development Coalition" aggregates the *Ministério de Desenvolvimento Agrário*, the *Presidência da República/Casa Civil*, the *Ministério de Minas e Energia*, the majority of the *Congresso Nacional*, the companies Petrobras and Brasil Ecodiesel and *CONTAG* which share the perspective that biodiesel production can foster social development. The policy core of this coalition is that the small farmers can provide a substantial share of the feedstock for the biodiesel and that the integration of these farmers into the value chain has to be promoted by regulations.

The "Biodiesel Agribusiness Coalition" aggregates the *Ministério da Agricultura, Pecuária e Abastecimento*, the association of the biodiesel producers *UBRABIO* and the plant manufacturer Dedini. In the perspective of these actors, biodiesel can help to promote the development of the oilseeds and more specifically the soyoil sector in Brazil. The policy core of this coalition is that biodiesel should be supported indistinctive of the feedstock and the region so that economic feasibility will decide upon supply and structure of feedstock and biodiesel production.

148 "We are concerned about the satisfaction of our clients, because for the client it is not very clear that a problem with the vehicle may be due to the fuel."

The “Biodiesel Technology and Quality Control Coalition” assembles the *Ministério da Ciência e Tecnologia*, the regulatory agency *ANP*, the association of the distribution companies *SINDICOM* and the association of the car manufacturers *ANFAVEA*. They see biodiesel as an important energy carrier and their policy core is that strong regulations and enforcement of these regulations with regard to the quality of the biodiesel and diesel fuel is necessary for fair competition and consumer protection.

Table 40 – Positions of advocacy coalitions in the biodiesel policy arena

| Policy problem | “Biodiesel Social Development Coalition“ | “Biodiesel Agribusiness Coalition“ | “Biodiesel Technology and Quality Control Coalition“ |
|---|---|---|---|
| Introduction of new fuel biodiesel into the market | No mandatory blend<br><br>changes in 2006 to: mandatory blend justifies auctions for biodiesel with social seal | Rapid introduction of mandatory blend, rapid increase of biodiesel share | Against high mandatory blend due to lack of information on impact on engines |
| Higher costs for biodiesel compared to diesel | Tax exemption for biodiesel with social seal and from North, Northeast, Semi-Arid | Tax exemptions shall equally be granted to all regions and production modes | No tax exemptions for biodiesel since this may foster tax evasion |
| Biodiesel fuel quality | Few limits, otherwise feedstocks or conversion pathways may be excluded | - | Biodiesel standard with defined limits |

Selected policy problems and the different positions of the actors shall illustrate the main differences between the coalitions. With regard to the policy problem of the “Introduction of the new fuel biodiesel into the market”, the “Biodiesel Social Development Coalition” is cautious with a rapid introduction of the mandatory blend since they believe that the integration of the small farmers into the biodiesel value chain will take some time and that a fast implementation of the mandatory blend would favour well developed value chains like the soy sector. The “Biodiesel Agribusiness Coalition” favours the rapid introduction and increase of the mandatory blend for the development of a large biodiesel demand as an alternative market for the processed soyoil. However, when the MP 214 was transformed into Law 11.097 by the *Congresso Nacional*, a mandatory blend starting in 2008 was introduced. The “Biodiesel Social Development Coalition” changed its position in a good example for policy learning and used the mandatory blend of B2 and the anticipation of B5 to guarantee a market share for biodiesel producers holding the social seal. The actors from the “Biodiesel Technology and Quality Control Coalition” are not completely against a rapid introduction of the mandatory blend but due to the lack of information about the impacts of higher biodiesel blends on engines, they ask for a slow implementation and the realisation of tests to improve the data basis for evaluation.

With regard to the policy problem of “higher costs for biodiesel compared to diesel”, the “Biodiesel Social Development Coalition” asks for tax exemption for biodiesel produced with raw material from small farmers and in the semi-arid to increase competitiveness of this biodiesel to offset additional costs linked to the organisation of the decentralised value chain. Since the coalition fears the rejection of this proposal by actors from the “Biodiesel Agribusiness Coalition” which favours tax exemption for all biodiesel production, the political regulations are enacted by a provisory measure. The actors from the

“Biodiesel Technology and Quality Control Coalition” are against the different tax treatment of diesel and biodiesel in general since this may foster adulteration of fuels and create quality problems. The “biodiesel fuel quality” is the main preoccupation of this coalition and this is why it asks for the rapid definition of biodiesel standards. But since the “Biodiesel Social Development Coalition” fears that rigid biodiesel standards may obstruct use of B100 and/or blends with high percentage of feedstocks like castor oil that are primarily produced by small farmers, many biodiesel standards are only defined later during the implementation of the biodiesel programme.

# 6. Conclusions

The objective of this dissertation was to analyse the current ethanol and biodiesel policies in Brazil and to explain these public policies as a result of the interactions and resources of various actors involved into the formulation and implementation of these policies, since existing studies about Brazilian biofuel production often neglect such an analysis of the institutional framework and the main policy actors. The methodological toolbox of the advocacy coalition approach by Sabatier (1993) was used to analyse the structure as well as the actors and the coalitions that dominate in the selected policy fields and several qualitative expert interviews were conducted during field research in Brazil between January and September 2007 following the methodological recommendations of Bogner, Littig and Menz (2005) and Laudel and Gläser (2004).

The analysis of the main biofuel policies in chapter 3 revealed that Brazilian ethanol support policies changed considerably during the last thirty years. During *PROALCOOL* competitiveness of ethanol was regulated directly by price control of the feedstock, the end products (sugar and ethanol) and the product to be substituted (gasoline) during, and ethanol production was subsidised heavily through national and international loans with very low interest rates. Nowadays, public support may appear limited at a first glance, but public credit lines for ethanol plants with low interest rates, tax incentives for hydrated ethanol and flexible-fuel vehicles and the mandatory blending still represent important support policies for ethanol production and consumption. Since biodiesel is not used as a neat fuel, differentiated tax treatment is not as important as in the case of ethanol. But other support policies (e.g. credit guarantees, mandatory blending, and several programmes for R&D in biodiesel feedstock cultivation and production technologies) are quite similar to those of the ethanol sector. But the social seal and the biodiesel auctions are a peculiarity of the biodiesel sector and a result of the social objectives of the biodiesel programme. While during *PROALCOOL* public support for biofuels was justified with the substitution of imported crude oil and derivates, the mitigation of greenhouse gases is used as the main legitimitation nowadays in international discussions on biofuels, but not necessarily in Brazil. The increase in energy provision and mobility continues to be the main justification for the promotion of biofuel production and consumption.

As described in chapter 4, ethanol and biodiesel production and consumption increased considerably in the past years, although from a very different base level. Brazil is the largest producer of sugarcane derived products worldwide and ethanol production is expanding rapidly in the Central-West region. Domestic consumption as well as ethanol exports increased in the past years. However, considering the world market ratio of international sugar and gasoline prices in the past years, sugar would have been the more feasible option for the producers theoretically for most of the time. At the domestic market, ethanol is competitive compared to gasoline as a neat fuel at petrol stations, but the competitiveness is limited to regions with a significant ethanol production like São Paulo. The competitiveness of ethanol is increased by tax advantages of hydrated ethanol compared to gasoline. For São Paulo state tax losses amounted to 1.6 billion USD in 2008, representing one fourth of theoretical tax revenues with fuels for spark ignition engines if ethanol fuel received the same tax treatment as gasoline fuel. Tax losses due to reduced taxation of FFV also increased and amounted to 294 million USD in 2008 for Brazil. But since total tax revenues with fuels for spark ignition engines as well as total tax revenues with *IPI* increased in São Paulo respectively in Brazil in the past years, tax losses are not being discussed controversially. Thus, FFV are not only substituting gasoline cars but contributing to the increasing overall light vehicle fleet in Brazil and ethanol has become a complementary energy carrier to gasoline rather than a substitute. This raises the question about the effectivity of ethanol fuel as a tool to mitigate GHG emissions and the justification of the support policies. The increasing energy demand follows the traditional international pattern of economic growth, but compared to other emergent markets Brazil's energy matrix continues to be less $CO_2$-intensive. However, due to the success of ethanol fuel, important alternatives to an individual transport infrastructure like investments in waterways and railways for example may not be sufficiently considered in Brazil.

In the biodiesel sector large production capacities were installed in Brazil in the past years and the demand for the 5% mandatory blend could be met already in 2010. Between 70% and 90% of the biodiesel is based on soyoil and since the soy processing industry in Brazil has large idle capacities the vegetable oil demand could be satisfied rapidly. Biodiesel production costs mainly depend on the feedstock costs and since all vegetable oils used for biodiesel production are internationally traded commodities, the biodiesel production costs follow the volatility of international vegetable oil prices. Considering the world market ratio of international vegetable oil and diesel fuel prices in the past years, the comercialisation of vegetable oil would have been the more feasible option for the biodiesel producers theoretically for most of the time, despite increasing gasoil prices. But since biodiesel is rarely exported and not offered as a neat fuel, the world market ratio and the competitiveness against fossil diesel only play a minor role compared to the situation in the ethanol sector. The market volume as well as the market prices are set by the government. If biodiesel producers shall be remunerated adequately in the biodiesel auctions international prices of the oilseed commodities have to be considered and this probably causes higher prices for biodiesel compared to fossil diesel. This means that additional costs for biodiesel – the fuel for the public mass and goods transport – probably will be passed to end consumers in terms of higher diesel fuel prices. However this hypothesis could not be validated in the thesis due to methodological difficulties. In the case of ethanol – the fuel for individual transport – the costs in terms of tax losses are passed on to the taxpayers by contrast.

The analysis of the main actors in chapter 5 revealed that there exist three advocacy coalitions in the ethanol policy arena. While the "Ethanol Social and Environmental Coalition" criticises the unregulated expansion of ethanol production, the other two coalitions rather represent different angles of the importance of ethanol fuel in Brazilian energy system than antagonistic beliefs and policy demands. The "Ethanol Social and Environmental Coalition" assembling the *Ministério do Meio Ambiente, dos Recursos Hídricos e da Amazônia Legal, WWF Brasil*, *Conservação Internacional, Comissão Pastoral da Terra, Movimento dos Trabalhadores sem Terra,* and the *Rede Social de Justiça e Direitos Humanos* emphasises the role of ethanol as a potential threat to biodiversity and the advancement of the Agrarian Reform. But the actors of this coalition are marginalised within the policy arena and do not manage to influence important political discussions and decisions. The "Ethanol Expansion Coalition" assembling the *Ministério da Agricultura, Pecuária e Abastecimento*, *Ministério do Desenvolvimento, Indústria e Comércio Exterior*, *Congresso Nacional*, *Presidência da República/Casa Civil*, *UNICA*, and Dedini emphasises the role of ethanol fuel as an important agricultural product and asks for long-term support policies necessary to expand ethanol production, consumption and exports. The "Ethanol Control Intensification Coalition" consisting of the *Ministério de Minas e Energia*, *ANP*, *SINDICOM*, Petrobras, and *ANFAVEA* emphasises the role of ethanol as an important energy carrier and stresses the importance to guarantee the quality of the ethanol fuel. With regard to the selected policy problem of the competitiveness of ethanol fuels vs. gasoline the "Ethanol Expansion Coalition" defends the interests of ethanol producers and suppliers and asks for federal tax incentives for ethanol fuel and FFV while the "Ethanol Control Intensification Coalition" defends the interests of the gasoline producers and suppliers and rejects these tax incentives since they encourage fuel adulteration and tax evasion. But due to a general consensus on the importance and the beneficial impacts of ethanol production and consumption in

Brazil, the tax incentives are not really questioned and no major changes in legislation occur. With regard to the policy problem of the quality of the ethanol fuel the “Ethanol Control Intensification Coalition” asks for stronger control of the production and commercialisation of the ethanol fuel by the regulatory agency *ANP* and a shift of the taxation to the ethanol producers but this is rejected by the “Ethanol Expansion Coalition”. The rejection of these changes is partly successful in the case of hydrated ethanol taxation, but some minor changes in the control of the ethanol commercialisation are implemented. The policy problem of the expansion of the international ethanol fuel market and trade does not divide but rather unifies the actors from both coalitions.

Within the biodiesel policy arena, three different coalitions could be identified. The “Biodiesel Social Development Coalition” aggregates the *Ministério de Desenvolvimento Agrário*, the *Presidência da República/Casa Civil*, the *Ministério de Minas e Energia*, the *Congresso Nacional*, the companies Petrobras and Brasil Ecodiesel and *CONTAG* which share the perspective that biodiesel production can promote social development and that regulations are needed for the integration of small farmers into the value chain. The “Biodiesel Agribusiness Coalition” aggregates the *Ministério da Agricultura, Pecuária e Abastecimento*, the association of the biodiesel producers *UBRABIO* and the plant manufacturer Dedini which share the perspective that biodiesel can help to promote the development of the oilseeds and more specifically the soyoil sector in Brazil. Thus, biodiesel should be supported indistinctive of the feedstock and the region so that economic feasibility will decide upon the supply and the structure of the feedstock and biodiesel production. The “Biodiesel Technology and Quality Control Coalition” assembles the Ministério da Ciência e Tecnologia, the regulatory agency ANP, the association of the distribution companies SINDICOM and the association of the car manufacturers ANFAVEA which all consider biodiesel an important energy carrier that needs strong regulations to guarantee the quality of the biodiesel. With regard to the policy problem of the introduction of the new fuel biodiesel into the market, the “Biodiesel Social Development Coalition” is cautious with a rapid introduction of the mandatory blend since it believes that a fast implementation of the mandatory blend would favour well developed value chains like the soy sector. Consequently, the “Biodiesel Agribusiness Coalition” favours the rapid introduction and increase of the mandatory blend for the development of a large biodiesel demand as an alternative market for the processed soyoil. The “Biodiesel Technology and Quality Control Coalition” asks for a slow implementation of the mandatory blend and the realisation of engine tests to improve data basis for evaluation of the impacts on the engines. As the main policy output, a mandatory blend starting already in 2008 is introduced by the *Congresso Nacional*, but the “Biodiesel Social Development Coalition” uses the mandatory blend of B2 and the anticipation of B5 to guarantee a market share for biodiesel producers holding the social seal – a successful example for policy learning of a coalition through a change in secondary aspects. With regard to the policy problem of the higher costs for biodiesel compared to diesel fuel, the “Biodiesel Social Development Coalition” asks for differentiated tax reductions for biodiesel with the social seal and fears the rejection of this proposal by the “Biodiesel Agribusiness Coalition” which favours general tax reductions for biodiesel. The “Biodiesel Technology and Quality Control Coalition” is against the different tax treatment of diesel and biodiesel since this may foster adulteration of fuels and create quality problems. However, the differentiated taxation of biodiesel considering small farmer participation, the raw material and the region is implementated by the president and is left unchanged when the provisory measure N° 227 (06/12/2004) is transformed into Law N° 11.116 (18/05/2005) by the *Congresso Nacional*. The policy problem of the quality of the biodiesel fuel is the main concern of the “Biodiesel Technology and Quality Control Coalition” which asks for the rapid definition of biodiesel standards. But since the “Biodiesel Social Development Coalition” fears that rigid biodiesel standards may exclude the use of feedstocks that are primarily produced by small farmers, many threshold values for parameters are only defined later during the implementation of the biodiesel programme.

By analysing the main ethanol and biodiesel policies and by realising and interpreting the expert interviews, the formulation and the implementation of the main policies could be explained by the positions and interactions of the most important policy actors in the two policy arenas. In the ethanol policy arena there is a broad consensus due to increasing ethanol production, increasing FFV sales and increasing tax revenues, and the structure of the actors is relatively homogeneous since ethanol production is only based on sugarcane concentrated in the Centre-South region and especially São Paulo. In the biodiesel policy arena by contrast, the discussions about the mandatory blend, the taxation of biodiesel and fossil diesel and the biodiesel standard reflect North vs. South and Family Agriculture vs. Agribussines cleavages. Despite the predominance of soybeans in Brazilian oilseed production, the policies aim at promoting other feedstocks and these contribute considerably to biodiesel production. This example proves that while general conditions like climate, agricultural structure, and production technologies may favour the use of specific biofuel feedstocks, the main patterns of biofuel production development are not predetermined by such factors but also the result of the political interactions and decisions analysed in this thesis.

Surprisingly, compared to European countries for example, the discussion about the impacts of these policies is not very controversial. The undoubted relative success of Brazilian biofuel and more specifically ethanol production compared to biofuel production of many other countries may simply disguise undeniable negative impacts of this success or may not be questioned in order not to compromise the export of the Brazilian success story to other countries. However, the dissertation illustrated that particularly in this case it is necessary to analyse also the specific political-regulatory framework that has enabled the expansion of biofuel production and consumption in Brazil.

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# Annexes

## Tables

Table 41 – List of realised interviews between 2006 and 2007

| Code | Organisation | Interviewee | Function | Department | Date | Local |
|---|---|---|---|---|---|---|
| Area | Political sector | | | | | |
| Cate-gory | Federal ministries | | | | | |
| A1 | Casa Civil | Rodrigo Augusto Rodrigues | Biodiesel Federal Program Coordinator | Analysis and Following Up Government Policies | 29/05/2007 | Brasília |
| A1 | MDIC | Eduardo von Glehn Nobre | Analista de Comércio Exterior | | 30/05/2007 | Brasília |
| A1 | MCT | Adriano Duarte Filho | General Coordinator for Sector Technologies | | 01/06/2007 | Brasília |
| A1 | MME | Marlon Arraes Jardim Leal | General Coordinator | Renewable Fuels Department | 01/06/2007 | Brasília |
| A1 | MDA | Alice Guimarães | Coordinator GTZ/DED/MDA Project | | 29/05/2007 | Brasília |
| A1 | MDA | Arnoldo Campos | | Secretaria de AF, Agregação de Valor e Renda | 06/06/2007 | Brasília |
| A1 | MAPA | Alexandre Strapasson | General Coordinator | Sugar and Ethanol Department | 01/06/2007 | Brasília |
| A1 | MMA | Shigeo Shiki | Assessor | Secretary for Sustainable Development Policies | 06/06/2007 | Brasília |
| Cate-gory | Others | | | | | |
| A2 | ANP | Marcus Vinícius Quintanilha | | Superintendence for the supply control | 28/09/2007 | Rio de Janeiro |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | Werner and Wilson L. R. Esteves | | | | |
| A2 | ANP | Roberto Furlan Ardenghy | Superintendent | Superintendence for the supply control | | Rio de Janeiro |
| A2 | Apex Brasil | Eduardo de F. Caldas | Project Manager | | | Brasília |
| A2 | BNDES | Ricardo Cunha da Costa | Project Manager | Área de Infra-estrutura, Energia | 22/02/2006 | Rio de Janeiro |
| A3 | Prefeitura de Piracicaba | Luciano Almeida | Secretary | Industry and Commerce | 25/01/2007 | Piracicaba |
| A3 | PSDB/SP | Antonio Carlos Mendes Thame | Federal Deputy | | 29/05/2007 | Brasília |
| A3 | EPE | Gelson Serva Baptista and Frederico Ventorim | Superintendent and Assistant | Gas and Biofuels | 28/09/2007 | Rio de Janeiro |
| Area | Biofuel sector | | | | | |
| B | Granol | Paulo Donato | Director | Crushing and Biodiesel Unit | 05/06/2007 | Anápolis |
| B | Bertin | César Abreu | Diretor Industrial | | 25/04/2007 | Lins |
| B | CTC | William Lee Burnquist | Manager for Strategic Development | | 30/08/2007 | Piracicaba |
| B | Fertibom | Lídio Pereira da Silva Junior and Geraldo Guilherme Neuber Martins | Director | | 2006 | Catanduva |
| Area | Technology, energy and logistic sector | | | | | |
| C1 | Dedini | José Luiz Olivério | Vice-president | Operations | 23/01/2007 | Piracicaba |
| C1 | Westfalia | Lincoln Camargo Neves | Assistant | Food Division: Oils and Fats | 29/08/2007 | Campinas |
| C1 | Bosch | Besaliel Botelho | Vice-president | Latin American activities | 27/04/2007 | Campinas |
| C1 | Lurgi | Fritz Thurm | General Manager | Latin American activities | | São Paulo |
| C1 | NG Metalúrgica | Gustavo Zanatta | Sales Engineer | | 05/04/2007 | Piracicaba |
| C2 | Petrobras | Luthero Winter | | Comercialisation of | 25/09/2007 | Rio de |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | Moreira | | Alcohol and Oxygenates | | Janeiro |
| C2 | Petrobras | Ricardo Mascarenhas | Coordinator | Gas and Power Energy Development | 2006 | Rio de Janeiro |
| C3 | Transpetro | Ubiracyr de O. Martins | Business Development Manager | | 13/08/2007 | Rio de Janeiro |
| C3 | Ecoflex | Fernando Campello and Leonardo Vidal or Marcelo Andrade | | | 10/08/2007 | Rio de Janeiro |
| Area | Business associations | | | | | |
| D | UNICA | Antonio de Pádua Rodrigues | Technical Director | | 03/04/2007 | |
| D | SINDICOM | Dietmar Schupp | | | 22/03/2007 | Rio de Janeiro |
| D | SINDICOM | Roberto Horn | | | 22/03/2007 | Rio de Janeiro |
| D | ANFA-VEA/VW | Henry Joseph Jr. | President of the Environmental Commission | | 02/04/2007 | São Paulo |
| Area | Workers organisations/Civil society | | | | | |
| E | CONTAG | Antoninho Rovaris | Secretary | Agricultural Policies | 31/05/2007 | Brasília |
| E | Orplana | Geraldo Majela de Andrade Silva | | | 31/08/2007 | Piracicaba |
| E | FETAESP | Braz Agostinho Albertini | Presidente | | 03/05/2007 | |
| E | WWF Brasil | Ilan Kruglianskas | | Agriculture and Environment Programme | 30/05/2007 | Brasília |
| E | Conservação Internacional Brasil | Paulo Gustavo de Prado Pereira | Director | Environmental Policy | 04/06/2007 | Brasília |
| E | CPT | Isidoro Revers | | National Secretary | 30/05/2007 | Brasília |
| Area | Research and development | | | | | |
| F | UFRJ/GEE | Edmar Luiz Fagundes de Almeida | | Instituto de Economia, Grupo de Energia | 25/07/2007 | Rio de Janeiro |

| | | | | | | |
|---|---|---|---|---|---|---|
| F | IPEA | Gervásio Castro de Rezende | | | 25/09/2007 | Rio de Janeiro |
| F | INT | Eduardo Caval-canti | | Researcher | 07/05/2007 | Rio de Janeiro |
| F | UFRJ | Luiz Guilherme da Costa Marques | | IVIG/Instituto de Química | 01/03/2007 | Rio de Janeiro |
| F | Embrapa Agroenergia | José Euripedes da Silva | | | 31/05/2007 | Brasília |
| F | UnB | Paulo Suarez | | Instituto de Química | 04/06/2007 | Brasília |
| F | UnB | João Nildo Vi-anna | | CSD | 04/06/2007 | Brasília |
| F | Unimep | Sebastião Neto Ribeiro Guedes | | Instituto de Econo-mia | 27/08/2007 | Piracicaba |
| F | ESALQ/USP | Marisa Regitano d'Arce | | | 23/01/2007 | Piracicaba |
| F | ESALQ/USP | Mirian R. P. Bacchi | | Centro de Estudos Avançados em Eco-nomia Aplicada | 23/01/2007 | Piracicaba |
| F | ESALQ/USP | Gerd Sparovek | | Departamento de Solos | 26/04/2007 | Piracicaba |
| F | ESALQ/USP | Marly Teresinha Pereira | | Economia/Sociologia | 25/01/2007 | Piracicaba |
| F | ESALQ/USP | Mauro Osaki | | CEPEA | 25/01/2007 | Piracicaba |
| F | Embrapa Monito-ramento por Satélite | Cristina Cri-ouscili and Fer-nando Quartero-li | | Remote sensing and geoprocessing | 29/08/2007 | Campinas |
| F | IEA | Thomas Fronzaglia | | | 03/04/2007 | São Paulo |

Table 42 – Anhydrous and hydrous ethanol production in Brazil 1974/75-2012/13 [m³] (Giersdorf, based on(Ministry of Agriculture, Livestock and Food Supply 2009; Companhia Nacional de Abastecimento 2012))

| Harvest season | Hydrated ethanol | Anhydrous ethanol | Total ethanol production |
|---|---:|---:|---:|
| 1974/75 | 378,457 | 216,528 | 594,985 |
| 1975/76 | 323,006 | 232,621 | 555,627 |
| 1976/77 | 363,982 | 300,340 | 664,322 |
| 1977/78 | 293,456 | 1,176,948 | 1,470,404 |
| 1978/79 | 395,006 | 2,095,597 | 2,490,603 |
| 1979/80 | 681,071 | 2,715,381 | 3,396,452 |

| | | | |
|---|---|---|---|
| 1980/81 | 1,601,086 | 2,105,289 | 3,706,375 |
| 1981/82 | 2,787,025 | 1,453,098 | 4,240,123 |
| 1982/83 | 2,273,634 | 3,549,405 | 5,823,039 |
| 1983/84 | 5,394,803 | 2,469,443 | 7,864,246 |
| 1984/85 | 7,089,744 | 2,102,585 | 9,192,329 |
| 1985/86 | 8,658,398 | 3,273,201 | 11,931,599 |
| 1986/87 | 8,343,243 | 2,163,469 | 10,506,712 |
| 1987/88 | 9,475,982 | 1,982,414 | 11,458,396 |
| 1988/89 | 9,928,392 | 1,716,490 | 11,644,882 |
| 1989/90 | 10,467,850 | 1,452,625 | 11,920,475 |
| 1990/91 | 10,228,583 | 1,286,568 | 11,515,151 |
| 1991/92 | 10,753,439 | 1,986,794 | 12,740,233 |
| 1992/93 | 9,513,106 | 2,216,385 | 11,729,491 |
| 1993/94 | 8,769,596 | 2,522,589 | 11,292,185 |
| 1994/95 | 9,892,440 | 2,873,470 | 12,765,910 |
| 1995/96 | 9,659,202 | 3,057,557 | 12,716,759 |
| 1996/97 | 9,801,109 | 4,629,340 | 14,430,449 |
| 1997/98 | 9,722,534 | 5,699,719 | 15,422,253 |
| 1998/99 | 8,246,823 | 5,679,998 | 13,926,821 |
| 1999/00 | 6,936,996 | 6,140,769 | 13,077,765 |
| 2000/01 | 4,932,805 | 5,584,730 | 10,517,535 |
| 2001/02 | 4,988,608 | 6,479,187 | 11,467,795 |
| 2002/03 | 5,476,363 | 7,099,063 | 12,575,426 |
| 2003/04 | 5,872,025 | 8,767,898 | 14,639,923 |
| 2004/05 | 7,035,421 | 8,172,488 | 15,207,909 |
| 2005/06 | 8,144,939 | 7,663,245 | 15,808,184 |
| 2006/07 | 9,211,462 | 8,220,715 | 17,432,177 |
| 2007/08 | 12,676,767 | 8,191,797 | 20,868,564 |
| 2008/09 | 10,063,711 | 16,619,714 | 26,683,425 |
| 2009/10 | 7,652,298 | 18,213,762 | 25,866,060 |
| 2010/11 | 6,949,840 | 18,812,782 | 25,762,622 |
| 2011/12 | 8,016,983 | 19,578,500 | 27,595,483 |
| 2012/13 | 9,749,374 | 15,176,286 | 24,925,660 |

Table 43 – Anhydrous and hydrous ethanol specifications in Brazil (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2005)

| Property | Unit | Anhydrous ethylic alcohol | Hydrous ethylic alcohol |
|---|---|---|---|
| Appearance | - | Clear and bright with no impurities | Clear and bright with no impurities |
| Color | - | Colourless before adding orange colorant | Colourless |
| Acidity | mg/L | 30 | 30 |
| Electrical Condutivity, max. | µS/m | 500 | 500 |
| Density at 20°C | Kg/m³ | 791.5 max. | 807.6 – 811.0 |
| Total Alcohol content | °INPM | 99.3 min. | 92.6-93.8 |
| pHe | - | - | 6.0-8.0 |
| Gum residue by evaporation, max. | mg/100Ml | - | 5 |
| Hydrocarbons, max. | %vol. | 3.0 | 3.0 |
| Chloride, max. | mg/kg | - | 1 |
| Ethanol content, min. | %vol. | 99.6 | 95.1 |
| Sulphate, max. | mg/kg | - | 4 |
| Iron, max. | mg/kg | - | 5 |
| Sodium, max. | mg/kg | - | 2 |
| Copper, max. | mg/kg | 0.07 | - |

Table 44 – Principal BNDES loans for sugar and ethanol investments 2007 (Banco Nacional de Desenvolvimento Econômico e Social 2010b)

| Company | Project description | Location | Date | Financial volume (BRL) |
|---|---|---|---|---|
| Usina Alto Alegre AS Açúcar e Álcool | Sugar and ethanol plant (2 m t cane); co-generation (35 MW) | Santo Inácio, PR | 05/01/2007 | 196,869,299 |
| | New administrative office | Presidente Prudente, SP | | 61,273,000 |
| Usina Boa Vista | Alcohol distillery (1.7 m t cane), 21,000 ha sugarcane, Co-generation (160 MW) | Quirinopolis, GO | 16/02/2007 | 248,205,487 |
| Da Mata SA – Açúcar e Álcool | Sugar and ethanol plant (1.2 m t cane) | Valparaiso, SP | 06/09/2007 | 197,117,992 |

| | | | | |
|---|---|---|---|---|
| Pedra Agroindustrial SA | Alcohol distillery (1.2 mio t cane), 12,900 ha sugarcane | Nova Independência, SP | 25/09/2007 | 152,102,870 |
| Açucareira Quatá SA | Co-generation expansion (7.32 MW to 41.8 MW), Expansion of crushing capacity (1.8 to 3.0 m t) | Quatá, SP | 13/07/2007 | 126,687,000 |
| Usina Ouroeste Açúcar e Álcool | Alcohol distillery (1.2 m t cane), 7,800 ha sugarcane | Ouroeste, SP | 24/01/2007 | 115,230,323 |
| Usina Santa Adélia SA | Alcohol distillery (1.5 m t cane) | Pereira Barreto, SP | 20/09/2007 | 106,490,993 |
| Tropical Bioenergia SA | Sugar and ethanol plant (2.4 m t cane), 23,100 ha sugarcane | Edéia/Porteirão, GO | 26/09/2007 | 102,787,001 |
| Açúcar e Álcool Camargo&Mendonça | Sugar and ethanol plant (0.85 m t), 9,454 ha sugarcane | Morrinhos, GO | 03/09/2007 | 98,107,077 |
| Usina Açucareira São Manoel SA | Expansion and modernization of ethanol and sugar plant | São Manoel, SP | 14/05/2007 | 97,146,945 |
| Antonio Ruette Agroindustrial Ltda | Sugar and ethanol plant (0.5 m t), 7,676 ha sugarcane | Ubarana, SP | 01/06/2007 | 93,537,141 |
| Floresta SA Açúcar e Álcool | Alcohol distillery, co-generation | Santo Antonio da Barra, GO | 14/08/2007 | 92,146,155 |
| Companhia Agrícola Quatá | Renovation and expansion of 36,150 ha sugarcane | Quatá, SP | 07/06/2007 | 72,330,164 |
| Usina Guariroba | Sugar and ethanol plant (0.95 m t) | Pontes Gestal, SP | 02/03/2007 | 71,797,965 |
| Jalles Machado SA | Expansion of sugar and ethanol plant, 12,000 ha sugarcane | Goianésia, GO | 09/11/2007 | 64,883,924 |
| Total value of principal loans | | | | 1,896,713,336 |

Table 45 – Principal BNDES loans for sugar and ethanol investments 2008 – 2009 (Banco Nacional de Desenvolvimento Econômico e Social 2010b)

| Company | Project description | Location | Date | Volume (BRL) |
|---|---|---|---|---|
| COSAN CENTROESTE S/A ACUCAR E ALCOOL | Ethanol plant (4 Mio. t sugarcane/a), Cogeneration (105 MW), sugarcane cultivation, environmental and social investments | Jatai, GO | GO 9/6/2009 | 635,719,506 |
| RIO CLARO AGROIN- | Three ethanol/sugar | Nova Alvorada do | IE 17/12/2008 | 419,513,867 |

| | | | | |
|---|---|---|---|---|
| DUSTRIAL LTDA | plants (incl. Cogeneration), sugarcane cultivation, environmental and social investments | Sul (MS), Cacu (GO), Mirante do Paranapanema (SP) | | |
| São Fernando Açúcar e Álcool | Ethanol and sugar plant (incl. cogeneration) | Dourados, MS | NO 12/12/2008 | 402,743,767 |
| Agro Energia Santa Luzia | Three ethanol/sugar plants (incl. Cogeneration), sugarcane cultivation, environmental and social investments | Nova Alvorada do Sul (MS), Cacu (GO), Mirante do Paranapanema (SP) | MS 17/12/2008 | 377,728,867 |
| Brenco Companhia Brasileira de Energia Renovável | SUPLEMENTACAO DE RECURSOS, VISANDO O EQUACIONAMENTO DE FUNDING PARA for three projects | | GO 3/2/2009 139.703.420<br><br>MS 3/2/2009 110.946.138<br><br>MT 3/2/2009 122.214.819 | 372,864,378 |
| Usina Conquista do Pontal | Three ethanol/sugar plants (incl. Cogeneration), sugarcane cultivation, environmental and social investments | Nova Alvorada do Sul (MS), Cacu (GO), Mirante do Paranapanema (SP). | SP 19/6/2009 | 355,522,988 |
| Iaco Agricola | Ethanol plant (incl. cogeneration, sugarcane cultivation, environmental and social investments | Chapada do Sul, MS. | MS 21/1/2009 | 244,583,067 |
| Biopav Açúcar e Álcool | First phase of agroindustrial complex (ethanol, sugar, yeast, electricity), 11,000 ha sugarcane cultivation | Brejo Alegre, SP | SP 2/10/2008 | 215,870,577 |
| Bioenergética Vale do Paracatu | Ethanol plant (3 Mio. t sugarcane/a), cogeneration, sugarcane cultivation, environmental and social investments | João Pinheiro, MG | MG 14/5/2009 | 96,969,000 |
| Codora Energia | Ethanol plant, Cogeneration (38.6 MW), sugarcane cultivation, environmental and social investments | | GO 30/6/2009 | 74,959,000 |
| FIP Terra Viva – Fundo de investimento em participações | Implementation of investment fond for sugar and ethanol companies | | IE 9/1/2009 | 63,300,000 |

| | | | | |
|---|---|---|---|---|
| Açúcareira Quata | Amplification, flexibilisation and modernisation of the units of the group, R&D in the area of microbiology | | SP 10/6/2009 | 55,676,445 |
| Jalles Machado | Ethanol plant, Cogeneration (38.6 MW), sugarcane cultivation, environmental and social investments | | GO 30/6/2009 | 52,291,043 |
| Usina Nova Gália | Ethanol and sugar plant, 1.5 Mio. t sugarcane/a | Parauna, GO | GO 12/2/2009 | 19,951,755 |
| Brenco Holding | SUPLEMENTACAO DE RECURSOS, VISANDO O EQUACIONAMENTO DE FUNDING PARA O PROJETO ORIGINAL. | | IE 16/6/2009 | 225,700,000 |
| Total value of principal loans | | | | 3,613,394,260 |

Table 46 – Biodiesel auctions 2005 – 2010 (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2010f)

| Auction | Date | Supply period | Offered Volume ($m^3$) | Lot | Sold volume ($m^3$) | Medium sale price (BRL/$m^3$) |
|---|---|---|---|---|---|---|
| 1 | 11/2005 | 01-12/2006 | 92,500 | - | 70,000 | 1,904 |
| 2 | 03/2006 | 07/2006-06/2007 | 315,520 | - | 170,000 | 1,860 |
| 3 | 07/2006 | 01-12/2007 | 125,400 | - | 50,000 | 1,754 |
| 4 | 07/2006 | 01-12/2007 | 1,141,335 | - | 550,000 | 1,747 |
| 5 | 02/2007 | 02-12/2007 | 50,000 | - | 45,000 | 1,862 |
| 6 | 11/2007 | 01-06/2008 | 304,000 | - | 304,000 | 1,867 |
| 7 | 11/2007 | 01-06/2008 | 76,000 | - | 76,000 | 1,863 |
| 8 | 04/2008 | 07-09/2008 | 473,140 | - | 264,000 | 2,692 |
| 9 | 04/2008 | 07-09/2008 | 181,810 | - | 66,000 | 2,685 |
| 10 | 08/2008 | 10-12/2008 | 347,060 | - | 264,000 | 2,605 |
| 11 | 08/2008 | 10-12/2008 | 94,760 | - | 66,000 | 2,610 |
| 12 | 11/2008 | 01-03/2009 | 449,890 | 1 | 264,000 | 2,386 |
| | | | | 2 | 66,000 | 2,389 |
| 13 | 02/2009 | 04-06/2009 | 578,152 | 1 | 252,000 | 2,223 |
| | | | | 2 | 63,000 | 1,885 |
| 14 | 05/2009 | 07-09/2009 | 645,624 | 1 | 368,000 | 2,307 |
| | | | | 2 | 92,000 | 2,317 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 15 | 08/2009 | 10-12/2009 | 684,931 | 1 | 368,000 | 2,264 |
| | | | | 2 | 92,000 | 2,275 |
| 16 | 11/2009 | 01-03/2010 | 725,179 | 1 | 460,000 | 2,329 |
| | | | | 2 | 115,000 | 2,319 |
| 17 | 03/2010 | 04-06/2010 | 565,000 | 1 | 452,000 | 2,242 |
| | | | | 2 | 113,000 | 2,218 |
| 18 | 05/2010 | 07-09/2010 | 600,000 | 1 | 480,000 | 2,193 |
| | | | | 2 | 120,000 | 1,754 |
| 19 | 08/2010 | 10-12/2010 | 615,000 | 1 | 492,000 | 1,750 |
| | | | | 2 | 123,000 | 1,720 |

Table 47 – Overview on public calls for R&D proposals on biodiesel in Brazil (Conselho Nacional de Desenvolvimento Científico e Tecnológico 2004; Conselho Nacional de Desenvolvimento Científico e Tecnológico 2007a; Conselho Nacional de Desenvolvimento Científico e Tecnológico 2007b; Conselho Nacional de Desenvolvimento Científico e Tecnológico 2008a; Conselho Nacional de Desenvolvimento Científico e Tecnológico 2008b; Conselho Nacional de Desenvolvimento Científico e Tecnológico 2008c; Conselho Nacional de Desenvolvimento Científico e Tecnológico 2008d; Conselho Nacional de Desenvolvimento Científico e Tecnológico 2008e; Financiadora de Estudos e Projetos 2005; Financiadora de Estudos e Projetos 2006)

| Call for proposals | Funding | Objective |
|---|---|---|
| MCT/CNPq N° 47/2008 | 4 Mio. BRL (FNDCT) | Characterisation and Quality Control of Biodiesel |
| MCT/CNPq N° 46/2008 | 8 Mio. BRL (FNDCT) | Obtention of Biodiesel via Ethylic Route |
| MCT/CNPq N° 30/2008 | 5 Mio. BRL (Ação Transversal IV, FNDCT+MCT) | Utilisation of co-products associated to the biodiesel value chain |
| MCT/CNPq N° 28/2008 | 4.5 Mio. BRL (CT-Agronegócio e Ação Transversal IV do FNDCT) | Cultivation of short rotation crops for the feedstock production for biodiesel |
| MCT/CNPq N° 26/2008 | 4.5 Mio. BRL (MCT/FNDCT and MPA[149]) | Microalgae as feedstock for biodiesel |
| MCT/CNPq N° 39/2007 | 17 Mio. BRL (CT-Agro + CT-Biotecnologia) | Advanced (Vanguard) Technologies for the production of ethanol and biodiesel<br><br>Thematic Line 2: Scientific and technological innovations for the feedstock and industrial biodiesel production |
| MCT/CNPq N° 31/2007 | 5 Mio. BRL (CT-Petro + CT+Agro) | Education and Fixation of Human Resources in the Biofuel Sector<br><br>Biodiesel production via cracking, |

[149] Ministério de Pesca e Aqüicultura (Ministry for Fishing and Aquaculture, created in 2009)

| | | |
|---|---|---|
| | | esterification, transesterification of fatty acids and/or their derivates and processes of purification of biodiesel and their effluents |
| MCT/FINEP 10/2006 | 4 Mio. BRL (Ação Transversal, CT-Agro + CT-ENERG) | Biodiesel production via cracking, esterification, transesterification of fatty acids and/or their derivates and processes of purification of biodiesel and their effluents |
| MCT/FINEP 11/2005 | 2 Mio. BRL (Ação Transversal, CT-Petro) | Technological development within the National Biodiesel Programme |
| MCT/CNPq N° 28/2004 | 1.57 Mio. BRL (CT-Amazônia, CT-Agro, Fundo Verde-Amarelo e CT-Petro) | Production of oilseeds in the states of the North region |

Table 48 – Specifications for diesel fuel in Brazil and the European Union (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2006b; European Committee for Standardization 2004)

| Property | Unit | Brazil<br><br>ANP N° 15[150] (19/7/2006) | EU<br><br>EN 590 |
|---|---|---|---|
| COMPOSITION | | | |
| Biodiesel Content | % vol. | 2.0 | 5.0[151] |
| Total sulphur content, max. | mg/kg | 500<br><br>(2,000)<br><br>50[152] | 10 |
| VOLATILITY | | | |
| Distillation<br><br>10% vol., recovered at<br><br>50% vol., recovered at<br><br>85% vol., recovered at | °C | <br><br>Report<br><br>245-310<br><br>360 (370) | <br><br>--<br><br>--<br><br>-- |

150 Because of emission control, Brazilian standard differentiates between interior diesel and metropolitan diesel. In explicitly defined metropolitan regions, only the metropolitan diesel can be commercialized. Values for the less restrictive interior diesel are set in brackets.
151 Maximum value for fatty acid methyl ester content
152 ANP Resolution N° 32 (17/10/2007) introduced low-sulphur (50 mg/kg) diesel standard for diesel cars that will be commercialised from 1st of January of 2009 on and whose emissions have to comply with more restrictive limits as established in Phase P-6 of the Programme for Emission Control of Automotive Vehicles *PROCONVE* (*Programa de Controle da Poluição do Ar por Veículos Automotores*).

| | | | |
|---|---|---|---|
| 90% vol., recovered at<br><br>95% vol., recovered at | | Report<br><br>-- | --<br><br>360 |
| Distillation,<br><br>recovered at 250 °C<br><br>recovered at 350 °C<br><br>recovered at 370 °C | % vol. | <br><br>--<br><br>--<br><br>-- | <br><br>max. 65<br><br>min. 85<br><br>min. 95 |
| Density at 20 °C | Kg/m³ | 820-865<br><br>(820-880)<br><br>820-850[153] | 845[154] |
| Flash Point, min. | °C | 38.0 | 55.0 |
| FLUIDITY | | | |
| Viscosity at 40 °C | mm²/s | 2.0-5.0 | 2.0-4.5 |
| Cold Filter Plugging Point, max. | °C | 0/+12[155] | -20/0[156] |
| COMBUSTION | | | |
| Cetane number, min. | | 42<br><br>46[157] | 51[158] |
| Cetane index, min. | | 45 | 46 |
| Carbon residue (on 10% distillation residue), max. | % mass | 0.25 | 0.30 |
| Ash content | % mass | 0.01 | 0.01 |
| CORROSION | | | |
| Copper strip corrosion (3 hours at 50 °C), max. | | Class 1 | Class 1 |
| CONTAMINANTS | | | |
| Water and sediments, max. | % volume | 0.05 | -- |
| Water content, max. | mg/kg | -- | 200 |
| Total contamination | mg/kg | -- | 24 |
| LUBRICITY | | | |
| Lubricity, max. | µm | 460 | 460 |

153 Limit for low-sulphur diesel (S-50)
154 Density at 15 °C
155 Limit varies according to region and month
156 Limit for Germany, varies according to season
157 Limit for low-sulphur diesel (S-50)
158 49 in Germany

Table 49 – Sugarcane area and ethanol and sugar production in Brazil 2012/13 (Companhia Nacional de Abastecimento 2012)

| | Area of sugarcane [1,000 ha] | % of total sugarcane area | Production of ethanol [1,000 l] | % of total ethanol production | Production of sugar [1,000 t] | % of total sugar production |
|---|---|---|---|---|---|---|
| North | 42 | 0.5% | 215,838 | 0.8% | 56 | 0.1% |
| Roraima | 3 | 0.0% | 12,172 | 0.0% | 0 | 0.0% |
| Amazonia | 4 | 0.0% | 6,291 | 0.0% | 15 | 0.0% |
| Pará | 11 | 0.1% | 34,360 | 0.1% | 40 | 0.1% |
| Tocantins | 24 | 0.3% | 158,911 | 0.6% | 0 | 0.0% |
| | | | | | | |
| Northeast | 1,114 | 13.1% | 1,670,106 | 7.1% | 4,261 | 11.3% |
| Maranhao | 42 | 0.5% | 171,362 | 0.7% | 7 | 0.0% |
| Piauí | 15 | 0.2% | 42,298 | 0.2% | 63 | 0.2% |
| Ceará | 2 | 0.0% | 11,898 | 0.1% | 0 | 0.0% |
| Rio Grande do Norte | 59 | 0.7% | 78,918 | 0.3% | 157 | 0.4% |
| Paraíba | 125 | 1.5% | 291,675 | 1.2% | 264 | 0.7% |
| Pernambuco | 328 | 3.8% | 252,369 | 1.1% | 1,429 | 3.8% |
| Alagoas | 446 | 5.2% | 502,301 | 2.1% | 2,119 | 5.6% |
| Sergipe | 45 | 0.5% | 132,577 | 0.6% | 103 | 0.3% |
| Bahia | 52 | 0.6% | 186,705 | 0.8% | 119 | 0.3% |
| | | | | | | |
| Central-West | 1,504 | 17.7% | 5,981,354 | 25.3% | 4,124 | 10.9% |
| Mato Grosso | 236 | 2.8% | 997,277 | 4.2% | 496 | 1.3% |
| Mato Grosso do Sul | 543 | 6.4% | 1,844,441 | 7.8% | 1,709 | 4.5% |
| Goiás | 726 | 8.5% | 3,139,635 | 13.3% | 1,919 | 5.1% |
| | | | | | | |
| Southeast | 5,249 | 61.6% | 14,440,888 | 61.1% | 26,162 | 69.5% |
| Minas Gerais | 722 | 8.5% | 2,340,688 | 9.9% | 3,232 | 8.6% |
| Espírito Santo | 62 | 0.7% | 180,460 | 0.8% | 142 | 0.4% |
| Rio de Janeiro | 45 | 0.5% | 71,234 | 0.3% | 106 | 0.3% |
| Sao Paulo | 4,419 | 51.9% | 11,848,504 | 50.2% | 22,682 | 60.2% |
| | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| South | 612 | 7.6% | 1,315,941 | 5.6% | 3,061 | 8.1% |
| Paraná | 611 | 7.5% | 1,314,276 | 5.6% | 3,061 | 8.1% |
| Rio Grande do Sul | 2 | 0.0% | 1,665 | 0.0% | 0 | 0.0% |
| | | | | | | |
| Brazil | 8,521 | 100.0% | 23,624,129 | 100.0% | 37,664 | 100.0% |

Table 50 – Monthly registrations of light vehicles and monthly sales of gasoline and ethanol fuel in Brazil, 2005-2010 (Associação Nacional dos Fabricantes de Veículos Automotores 2010b; Associação Nacional dos Fabricantes de Veículos Automotores 2011b; Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2011a)

| Month | Gasolina C consumption in litres | Hydrated ethanol consumption in litres of GE | Total light vehicles registrations | Thereof registrations of flexible-fuel vehicles |
|---|---|---|---|---|
| 2005 | | | | |
| January | 1,843,908 | 243,256 | 90,980 | 26,342 |
| February | 1,805,672 | 224,261 | 104,372 | 31,937 |
| March | 2,062,840 | 249,003 | 136,446 | 50,227 |
| April | 1,917,475 | 238,331 | 124,037 | 51,371 |
| May | 1,963,681 | 252,778 | 126,191 | 66,954 |
| June | 1,956,777 | 258,671 | 128,473 | 71,990 |
| July | 1,940,779 | 259,787 | 119,292 | 71,970 |
| August | 2,053,537 | 285,326 | 136,641 | 89,758 |
| September | 1,984,885 | 311,699 | 129,460 | 91,210 |
| October | 1,873,755 | 286,133 | 116,708 | 81,870 |
| November | 1,920,306 | 299,035 | 138,255 | 104,090 |
| December | 2,229,875 | 358,776 | 140,469 | 108,991 |
| 2006 | | | | |
| January | 1,926,858 | 346,998 | 119,418 | 92,004 |
| February | 1,874,940 | 332,184 | 122,739 | 95,658 |
| March | 2,040,355 | 297,252 | 149,195 | 114,108 |
| April | 1,947,975 | 273,516 | 131,769 | 100,228 |
| May | 2,007,190 | 332,112 | 151,131 | 119,897 |
| June | 1,934,165 | 338,825 | 140,773 | 114,055 |
| July | 1,928,606 | 359,363 | 146,427 | 116,650 |
| August | 2,062,841 | 376,045 | 160,489 | 134,042 |
| September | 2,052,914 | 396,325 | 149,065 | 124,002 |

| | | | | |
|---|---|---|---|---|
| October | 2,022,895 | 398,288 | 157,448 | 132,289 |
| November | 1,961,920 | 408,941 | 166,335 | 143,918 |
| December | 2,246,973 | 470,739 | 162,981 | 137,261 |
| 2007 | | | | |
| January | 1,976,896 | 444,165 | 136,291 | 121,938 |
| February | 1,844,983 | 406,406 | 136,181 | 118,272 |
| March | 2,083,408 | 488,532 | 182,279 | 155,901 |
| April | 1,973,344 | 452,096 | 170,110 | 146,984 |
| May | 2,042,570 | 469,948 | 191,683 | 169,754 |
| June | 2,007,011 | 496,173 | 190,189 | 171,558 |
| July | 1,992,885 | 532,763 | 199,811 | 182,929 |
| August | 2,069,938 | 585,331 | 219,603 | 196,919 |
| September | 1,923,142 | 573,468 | 205,058 | 181,289 |
| October | 2,121,191 | 694,501 | 231,562 | 210,235 |
| November | 2,016,819 | 684,716 | 221,105 | 201,865 |
| December | 2,273,262 | 728,686 | 190,963 | 174,717 |
| 2008 | | | | |
| January | 2,034,837 | 673,137 | 196,265 | 180,293 |
| February | 1,926,803 | 659,424 | 197,482 | 180,188 |
| March | 2,031,921 | 702,888 | 223,107 | 204,475 |
| April | 2,062,343 | 740,877 | 244,913 | 223,989 |
| May | 2,044,139 | 746,062 | 236,237 | 214,689 |
| June | 1,993,712 | 731,968 | 253,543 | 232,889 |
| July | 2,146,454 | 783,661 | 258,635 | 237,498 |
| August | 2,096,694 | 789,002 | 254,532 | 232,890 |
| September | 2,187,424 | 837,702 | 243,192 | 223,226 |
| October | 2,239,878 | 862,089 | 208,948 | 189,424 |
| November | 2,011,583 | 817,166 | 131,352 | 119,906 |
| December | 2,398,995 | 959,092 | 134,328 | 115,057 |
| 2009 | | | | |
| January | 2,039,273 | 876,836 | 189,712 | 163,545 |
| February | 1,914,531 | 820,592 | 191,335 | 166,812 |
| March | 2,071,668 | 919,495 | 260,924 | 231,963 |
| April | 2,084,110 | 971,041 | 224,379 | 197,981 |
| May | 1,970,897 | 919,449 | 237,378 | 210,485 |

| | | | | |
|---|---|---|---|---|
| June | 2,023,362 | 960,107 | 271,750 | 260,208 |
| July | 2,127,463 | 1,013,412 | 273,581 | 243,406 |
| August | 2,020,808 | 986,214 | 247,503 | 221,469 |
| September | 2,098,188 | 1,050,942 | 296,652 | 265,889 |
| October | 2,296,541 | 1,050,348 | 281,270 | 245,608 |
| November | 2,138,751 | 904,929 | 238,413 | 207,348 |
| December | 2,623,497 | 1,056,300 | 277,815 | 237,584 |
| 2010 | | | | |
| January | 2,448,435 | 685,326 | 201,701 | 172,030 |
| February | 2,385,364 | 563,345 | 211,348 | 184,303 |
| March | 2,663,940 | 758,855 | 337,346 | 296,363 |
| April | 2,412,309 | 856,753 | 261,878 | 226,725 |
| May | 2,332,079 | 922,929 | 235,753 | 201,435 |
| June | 2,323,568 | 940,765 | 247,480 | 213,301 |
| July | 2,424,926 | 993,944 | 285,210 | 248,175 |
| August | 2,415,108 | 973,150 | 296,594 | 257,320 |
| September | 2,465,610 | 994,507 | 291,434 | 250,727 |
| October | 2,487,206 | 941,702 | 287,575 | 247,094 |
| November | 2,525,660 | 917,218 | 311,397 | 269,515 |
| December | 2,959,459 | 1,003,517 | 361,230 | 309,183 |

Table 51 – Hydrated ethanol and Gasolina C prices at fuel stations between 01/2006 and 12/2010 in Bahia, Pará and São Paulo state [BRL/litre] (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2010c)

| Month | Hydrated ethanol (BRL/litre) | | | Gasolina C (BRL/litre) | | |
|---|---|---|---|---|---|---|
| | Bahia | Pará | São Paulo | Bahia | Pará | São Paulo |
| January-06 | 1.73 | 2.16 | 1.5 | 2.52 | 2.58 | 2.38 |
| February-06 | 1.75 | 2.25 | 1.55 | 2.53 | 2.59 | 2.37 |
| March-06 | 1.87 | 2.40 | 1.78 | 2.65 | 2.65 | 2.47 |
| April-06 | 1.93 | 2.44 | 1.73 | 2.64 | 2.66 | 2.47 |
| May-06 | 1.94 | 2.45 | 1.45 | 2.65 | 2.64 | 2.44 |
| June-06 | 1.89 | 2.40 | 1.31 | 2.63 | 2.61 | 2.42 |
| July-06 | 1.87 | 2.34 | 1.34 | 2.61 | 2.59 | 2.42 |
| August-06 | 1.85 | 2.30 | 1.36 | 2.62 | 2.57 | 2.42 |
| September-06 | 1.83 | 2.29 | 1.29 | 2.67 | 2.57 | 2.42 |
| October-06 | 1.75 | 2.24 | 1.24 | 2.65 | 2.56 | 2.42 |

| | | | | | | |
|---|---|---|---|---|---|---|
| November-06 | 1.69 | 2.11 | 1.20 | 2.59 | 2.52 | 2.40 |
| December-06 | 1.67 | 2.08 | 1.22 | 2.57 | 2.54 | 2.39 |
| January-07 | 1.70 | 2.12 | 1.37 | 2.65 | 2.54 | 2.41 |
| February-07 | 1.70 | 2.12 | 1.36 | 2.67 | 2.51 | 2.40 |
| March-07 | 1.70 | 2.13 | 1.36 | 2.67 | 2.48 | 2.39 |
| April-07 | 1.72 | 2.15 | 1.44 | 2.67 | 2.49 | 2.41 |
| May-07 | 1.75 | 2.22 | 1.46 | 2.64 | 2.6 | 2.44 |
| June-07 | 1.68 | 2.16 | 1.31 | 2.53 | 2.59 | 2.42 |
| July-07 | 1.63 | 2.00 | 1.20 | 2.61 | 2.57 | 2.40 |
| August-07 | 1.57 | 1.95 | 1.13 | 2.51 | 2.56 | 2.38 |
| September-07 | 1.53 | 1.94 | 1.10 | 2.45 | 2.56 | 2.37 |
| October 07 | 1.50 | 1.91 | 1.08 | 2.52 | 2.55 | 2.37 |
| November-07 | 1.53 | 1.94 | 1.19 | 2.55 | 2.54 | 2.37 |
| December-07 | 1.62 | 2.10 | 1.29 | 2.59 | 2.68 | 2.38 |
| January-08 | 1.62 | 2.14 | 1.29 | 2.56 | 2.70 | 2.38 |
| February-08 | 1.53 | 2.13 | 1.26 | 2.48 | 2.71 | 2.38 |
| March-08 | 1.46 | 2.13 | 1.27 | 2.40 | 2.71 | 2.38 |
| April-08 | 1.67 | 2.13 | 1.27 | 2.64 | 2.69 | 2.38 |
| May-08 | 1.76 | 2.13 | 1.28 | 2.67 | 2.69 | 2.40 |
| June-08 | 1.77 | 2.10 | 1.26 | 2.68 | 2.68 | 2.39 |
| July-08 | 1.81 | 2.09 | 1.25 | 2.68 | 2.68 | 2.39 |
| August-08 | 1.78 | 2.11 | 1.26 | 2.67 | 2.69 | 2.39 |
| September-08 | 1.77 | 2.12 | 1.27 | 2.66 | 2.77 | 2.39 |
| October-08 | 1.70 | 2.12 | 1.30 | 2.59 | 2.77 | 2.39 |
| November-08 | 1.59 | 2.11 | 1.31 | 2.50 | 2.77 | 2.40 |
| December-08 | 1.69 | 2.11 | 1.31 | 2.60 | 2.76 | 2.40 |
| January-09 | 1.74 | 2.09 | 1.31 | 2.65 | 2.75 | 2.39 |
| February-09 | 1.77 | 2.08 | 1.33 | 2.67 | 2.75 | 2.40 |
| March-09 | 1.75 | 2.07 | 1.32 | 2.67 | 2.75 | 2.39 |
| April-09 | 1.56 | 2.06 | 1.27 | 2.54 | 2.74 | 2.37 |
| May-09 | 1.45 | 2.05 | 1.25 | 2.43 | 2.74 | 2.37 |
| June-09 | 1.67 | 2.03 | 1.17 | 2.66 | 2.73 | 2.35 |
| July-09 | 1.69 | 2.00 | 1.20 | 2.67 | 2.73 | 2.35 |
| August-09 | 1.70 | 2.00 | 1.23 | 2.67 | 2.73 | 2.35 |
| September-09 | 1.70 | 1.97 | 1.31 | 2.67 | 2.72 | 2.37 |

| | | | | | | |
|---|---|---|---|---|---|---|
| October-09 | 1.84 | 2.10 | 1.50 | 2.67 | 2.73 | 2.41 |
| November-09 | 1.81 | 2.14 | 1.55 | 2.56 | 2.73 | 2.43 |
| December-09 | 1.77 | 2.15 | 1.60 | 2.53 | 2.75 | 2.44 |
| January-10 | 1.91 | 2.20 | 1.81 | 2.69 | 2.76 | 2.48 |
| February-10 | 2.03 | 2.28 | 1.83 | 2.77 | 2.79 | 2.51 |
| March-10 | 1.95 | 2.27 | 1.61 | 2.75 | 2.75 | 2.47 |
| April-10 | 1.86 | 2.13 | 1.48 | 2.74 | 2.70 | 2.44 |
| May-10 | 1.85 | 2.08 | 1.35 | 2.75 | 2.70 | 2.41 |
| June-10 | 1.83 | 2.01 | 1.27 | 2.73 | 2.75 | 2.40 |
| July-10 | 1.82 | 1.98 | 1.33 | 2.72 | 2.71 | 2.41 |
| August-10 | 1.80 | 1.98 | 1.39 | 2.70 | 2.69 | 2.41 |
| September-10 | 1.66 | 1.96 | 1.41 | 2.53 | 2.69 | 2.42 |
| October-10 | 1.86 | 2.01 | 1.56 | 2.68 | 2.71 | 2.46 |
| November-10 | 1.95 | 2.07 | 1.59 | 2.76 | 2.70 | 2.46 |
| December-10 | 1.95 | 2.08 | 1.67 | 2.75 | 2.70 | 2.48 |

Table 52 – World market ratio for ethanol and sugar production in Brazil 1997-2010 (selected price combinations) (International Energy Agency 2008; United States Energy Information Administration 2010a; United States Department of Agriculture 2012b)

| Month | World raw sugar price, Contract No. 11 FOB (US-cts/lb) | Amsterdam-Rotterdam-Antwerp (ARA) 10ppm Conventional Gasoline Regular Spot Price FOB (USD/bbl) |
|---|---|---|
| May 1996 | 11.94 | 25.14 |
| November 1996 | 11.29 | 24.67 |
| May 1997 | 11.54 | 22.93 |
| November 1997 | 13.19 | 22.30 |
| May 1998 | 10.17 | 17.98 |
| November 1998 | 8.73 | 14.21 |
| May 1999 | 5.83 | 18.20 |
| November 1999 | 6.54 | 27.33 |
| May 2000 | 7.33 | 30.49 |
| November 2000 | 10.02 | 32.98 |
| May 2001 | 9.96 | 39.25 |
| November 2001 | 7.80 | 20.26 |
| May 2002 | 7.33 | 29.35 |
| November 2002 | 8.87 | 27.88 |

| | | |
|---|---|---|
| November 2003 | 6.83 | 33.66 |
| May 2004 | 8.08 | 53.32 |
| November 2004 | 9.65 | 50.87 |
| May 2005 | 10.23 | 56.40 |
| November 2005 | 12.86 | 59.85 |
| May 2006 | 17.83 | 83.62 |
| November 2006 | 12.38 | 62.63 |
| May 2007 | 10.78 | 91.35 |
| November 2007 | 11.83 | 83.34 |
| June 2008 | 13.29 | 135.19 |
| February 2009 | 13.90 | 47.70 |
| March 2010 | 21.36 | 90.89 |
| November 2010 | 34.80 | 90.89 |
| January 2011 | 36.11 | 102.82 |

Table 53 – New vehicle registration159 by engine displacement and fuel type 2006-2008 (Associação Nacional dos Fabricantes de Veículos Automotores 2009a)

| 2006 | | | |
|---|---|---|---|
| Engine | Gasoline | FFV | Total |
| < 1 000 ccm | 157,756 | 713,727 | 871,483 |
| 1 000 – 2 000 ccm | 119,444 | 540,393 | 659,837 |
| > 2 000 ccm | 4,507 | 20,393 | 24,900 |
| Total | 281,708 | 1,274,512 | 1,556,220 |
| 2007 | | | |
| Engine | Gasoline | FFV | Total |
| < 1 000 ccm | 116,478 | 950,038 | 1,066,516 |
| 1 000 – 2 000 ccm | 96,281 | 785,299 | 881,580 |
| > 2 000 ccm | 2,995 | 24,427 | 27,422 |
| Total | 215,754 | 1,759,764 | 1,975,518 |
| 2008 | | | |
| Engine | Gasoline | FFV | Total |
| < 1 000 ccm | 94,609 | 1,015,450 | 1,110,059 |
| 1 000 – 2 000 ccm | 89,628 | 961,991 | 1,051,619 |
| > 2 000 ccm | 2,693 | 28,906 | 31,599 |

159 only passenger cars

| | | | |
|---|---|---|---|
| Total | 186,930 | 2,006,347 | 2,193,277 |

Table 54 – Renouncement on revenues from IPI for passenger cars in Brazil 2006-2008 (Giersdorf, based on (Emiliani and Figueiredo 2005; Morelli 2005; Presidência da República 2004c; Presidência da República 2006c; Presidência da República 2008e; Presidência da República 2009b)

| Engine displacement | ≤ 1,000 ccm | ≤ 2,000 ccm | > 2,000 ccm | Total |
|---|---|---|---|---|
| 2006 | | | | |
| Car sales | | | | |
| Gasoline | 116,478 | 96,281 | 2,995 | 215,754 |
| FFV | 950,038 | 785,299 | 24,427 | 1,759,764 |
| Total | 1,066,516 | 881,580 | 27,422 | 1,975,518 |
| Revenue with IPI | | | | |
| Gasoline (BRL) | 215,718,041 | 332,265,154 | 35,938,379 | 583,921,573 |
| FFV (BRL) | 1,759,469,591 | 2,334,694,424 | 223,581,568 | 4,317,745,583 |
| Total (BRL) | 1,975,187,632 | 2,666,959,578 | 259,519,946 | 4,901,667,156 |
| Total (USD) | 1,012,916,734 | 1,367,671,579 | 133,087,152 | 2,513,675,465 |
| Tax losses | | | | |
| BRL | 0 | 375,373,002 | 69,544,054 | 444,917,056 |
| USD | 0 | 192,498,975 | 35,663,617 | 228,162,593 |
| 2007 | | | | |
| Car sales | | | | |
| Gasoline | 157,756 | 119,444 | 4,507 | 281,708 |
| FFV | 713,727 | 540,393 | 20,393 | 1,274,512 |
| Total | 871,483 | 659,837 | 24,900 | 1,556,220 |
| Revenue with IPI | | | | |
| Gasoline (BRL) | 292,164,602 | 412,201,264 | 54,088,917 | 758,454,783 |
| FFV (BRL) | 1,321,821,914 | 1,606,588,372 | 186,653,378 | 3,115,063,664 |
| Total (BRL) | 1,613,986,516 | 2,018,789,636 | 240,742,296 | 3,873,518,447 |
| Total (USD) | 740,360,787 | 926,050,292 | 110,432,246 | 1,776,843,324 |
| Tax losses | | | | |
| BRL | 0 | 258,307,851 | 58,057,704 | 316,365,556 |
| USD | 0 | 118,489,840 | 26,631,974 | 145,121,815 |
| 2008 | | | | |
| Car sales | | | | |
| Gasoline | 94,609 | 89,628 | 2,693 | 186,930 |
| FFV | 1,015,450 | 961,991 | 28,906 | 2,006,347 |

| | | | | |
|---|---|---|---|---|
| Total | 1,110,059 | 1,051,619 | 31,599 | 2,193,277 |
| Revenue with IPI | | | | |
| Gasoline (BRL) | 175,215,369 | 309,306,136 | 32,317,647 | 516,839,152 |
| FFV (BRL) | 1,880,613,899 | 2,859,999,322 | 264,575,362 | 5,005,188,583 |
| Total (BRL) | 2,055,829,268 | 3,169,305,458 | 296,893,009 | 5,522,027,735 |
| Total (USD) | 1,117,298,515 | 1,722,448,619 | 161,354,896 | 3,001,102,030 |
| Tax losses | | | | |
| BRL | 0 | 459,831,711 | 82,294,991 | 542,126,702 |
| USD | 0 | 249,908,538 | 44,725,539 | 294,634,077 |

Table 55 – Soybean production in Brazil 1976/77-2010/11 (Ministry of Agriculture, Livestock and Food Supply 2009; Companhia Nacional de Abastecimento 2010; Companhia Nacional de Abastecimento 2011a)

| | Cultivated area in ha | Production in t | Productivity in kg/ha |
|---|---|---|---|
| 1976/77 | 6,900,000 | 12,150,000 | 1,761 |
| 1980/81 | 8,700,000 | 15,480,000 | 1,779 |
| 1985/86 | 9,600,000 | 13,210,000 | 1,376 |
| 1990/91 | 9,700,000 | 15,390,000 | 1,587 |
| 1995/96 | 10,700,000 | 23,190,000 | 2,167 |
| 2000/01 | 14,000,000 | 38,430,000 | 2,745 |
| 2005/06 | 22,200,000 | 53,430,000 | 2,407 |
| 2006/07 | 20,686,800 | 58,376,400 | 2,822 |
| 2007/08 | 21,016,100 | 59,583,000 | 2,835 |
| 2008/09 | 21,743,100 | 57,165,500 | 2,629 |
| 2009/10 | 23,239,000 | 67,864,600 | 2,920 |
| 2010/11 | 24,033,900 | 70,296,900 | 2,925 |

Table 56 – Oil palm cultivation production in Brazil 1975-2007 (Ministry of Agriculture, Livestock and Food Supply 2009, 70)

| Year | Cultivated area in ha | Bunch production in t | Productivity in kg/ha |
|---|---|---|---|
| 1975 | 3,300 | 35,000 | 10,606 |
| 1980 | 5,700 | 60,000 | 10,526 |
| 1985 | 13,500 | 145,000 | 10,741 |
| 1990 | 33,000 | 328,000 | 9,939 |
| 1995 | 33,000 | 328,000 | 9,939 |
| 2000 | 45,000 | 450,000 | 10,000 |

| | | | |
|---|---|---|---|
| 2001 | 45,000 | 450,000 | 10,000 |
| 2002 | 45,000 | 450,000 | 10,000 |
| 2003 | 51,600 | 516,000 | 10,000 |
| 2004 | 55,000 | 550,000 | 10,000 |
| 2005 | 56,000 | 560,000 | 10,000 |
| 2006 | 57,000 | 570,000 | 10,000 |
| 2007 | 57,000 | 570,000 | 10,000 |

Table 57 – Castor bean production in Brazil 1976/77-2010/11 (Ministry of Agriculture, Livestock and Food Supply 2009; Companhia Nacional de Abastecimento 2010; Companhia Nacional de Abastecimento 2011a)

| | Cultivated area in ha | Production in t | Productivity in kg/ha |
|---|---|---|---|
| 1976/77 | 249,900 | 201,500 | 806 |
| 1980/81 | 444,900 | 263,800 | 593 |
| 1985/86 | 441,400 | 272,200 | 617 |
| 1990/91 | 238,900 | 133,800 | 560 |
| 1995/96 | 121,500 | 47,600 | 392 |
| 2000/01 | 161,400 | 79,900 | 495 |
| 2001/02 | 126,100 | 72,400 | 574 |
| 2002/03 | 128,300 | 86,300 | 673 |
| 2003/04 | 166,200 | 107,300 | 646 |
| 2004/05 | 215,100 | 209,800 | 975 |
| 2005/06 | 147,900 | 103,900 | 703 |
| 2006/07 | 155,600 | 93,700 | 602 |
| 2007/08 | 158,200 | 130,400 | 825 |
| 2008/09 | 157,500 | 92,500 | 587 |
| 2009/10 | 139,800 | 104,100 | 745 |
| 2010/11 | 242,800 | 183,400 | 755 |

Table 58 – Cottonseed production in Brazil 1976/77-2010/11 (Ministry of Agriculture, Livestock and Food Supply 2009; Companhia Nacional de Abastecimento 2010; Companhia Nacional de Abastecimento 2011a)

| | Cultivated area in ha | Seed production in t | Productivity in kg/ha |
|---|---|---|---|
| 1976/77 | 4,096,000 | 1,180,000 | 288 |
| 1980/81 | 4,137,000 | 1,120,000 | 271 |
| 1985/86 | 3,325,000 | 1,480,000 | 445 |
| 1990/91 | 1,939,000 | 1,360,000 | 701 |

| | | | |
|---|---|---|---|
| 1995/96 | 953,000 | 760,000 | 797 |
| 2000/01 | 868,000 | 1,520,000 | 1,751 |
| 2001/02 | 748,000 | 1,240,000 | 1,658 |
| 2002/03 | 735,000 | 1,360,000 | 1,850 |
| 2003/04 | 1,100,000 | 2,100,000 | 1,909 |
| 2004/05 | 1,179,000 | 2,130,000 | 1,807 |
| 2005/06 | 857,000 | 1,670,000 | 1,949 |
| 2006/07 | 1,096,800 | 2,383,600 | 2,173 |
| 2007/08 | 1,091,500 | 2,434,100 | 2,230 |
| 2008/09 | 843,200 | 1,890,600 | 2,242 |
| 2009/10 | 836,000 | 1,993,800 | 2,385 |
| 2010/11 | 1,304,700 | 3,040,000 | 2,330 |

Table 59 – Sunflower seed production in Brazil 1976/77-2010/11 (Ministry of Agriculture, Livestock and Food Supply 2009; Companhia Nacional de Abastecimento 2010; Companhia Nacional de Abastecimento 2011a)

| | Cultivated area in ha | Production in t | Productivity in kg/ha |
|---|---|---|---|
| 1997/98 | 12,400 | 15,800 | 1,274 |
| 1998/99 | 44,300 | 49,000 | 1,106 |
| 1999/00 | 58,000 | 97,400 | 1,679 |
| 2000/01 | 37,000 | 56,300 | 1,522 |
| 2001/02 | 52,600 | 71,000 | 1,350 |
| 2002/03 | 43,200 | 56,400 | 1,306 |
| 2003/04 | 55,100 | 85,400 | 1,550 |
| 2004/05 | 50,100 | 68,100 | 1,359 |
| 2005/06 | 66,900 | 93,600 | 1,399 |
| 2006/07 | 75,400 | 106,100 | 1,407 |
| 2007/08 | 87,800 | 128,500 | 1,464 |
| 2008/09 | 75,000 | 109,400 | 1,459 |
| 2009/10 | 66,700 | 90,500 | 1,357 |
| 2010/11 | 73,400 | 110,100 | 1,500 |

Table 60 – Monthly Brazilian biodiesel production 2006-2010 [$m^3$] (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2011b)

| Month | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|
| January | 1,075 | 17,109 | 76,784 | 90,352 | 147,435 |

| | | | | | |
|---|---|---|---|---|---|
| February | 1,043 | 16,933 | 77,085 | 80,224 | 178,049 |
| March | 1,725 | 22,637 | 63,680 | 131,991 | 214,150 |
| April | 1,786 | 18,773 | 64,350 | 105,458 | 184,897 |
| May | 2,578 | 26,005 | 75,999 | 103,663 | 202,729 |
| June | 6,490 | 27,158 | 102,767 | 141,139 | 204,940 |
| July | 3,331 | 26,718 | 107,786 | 154,557 | 207,434 |
| August | 5,102 | 43,959 | 109,534 | 167,086 | 230,613 |
| September | 6,735 | 46,013 | 132,258 | 160,538 | 219,865 |
| October | 8,581 | 53,609 | 126,817 | 156,811 | 210,537 |
| November | 16,025 | 56,401 | 118,014 | 166,192 | 208,972 |
| December | 14,531 | 49,016 | 112,053 | 150,437 | 187,653 |
| Total | 69,002 | 404,329 | 1,167,128 | 1,608,448 | 2,397,272 |

Table 61 – Biodiesel production per region 2007-2010 [m³] (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2011b)

| Region | 2007 | | 2008 | | 2009 | | 2010 | |
|---|---|---|---|---|---|---|---|---|
| North | 26,589 | 7% | 15,987 | 1% | 41,821 | 3% | 93,880 | 4% |
| Northeast | 172,200 | 43% | 125,910 | 11% | 163,905 | 10% | 186,297 | 8% |
| Centre-West | 125,808 | 31% | 526,287 | 45% | 640,077 | 40% | 1,018,302 | 42% |
| Southeast | 37,023 | 9% | 185,594 | 16% | 284,379 | 17% | 423,123 | 18% |
| South | 42,708 | 11% | 313,350 | 27% | 477,871 | 30% | 675,668 | 28% |
| Total | 404,329 | 100% | 1,167,128 | 100% | 1,608,053 | 100% | 2,397,270 | 100% |

Table 62 – Demand, production and balance of biodiesel in Brazilian regions 2010 [m³] (Giersdorf, based on (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2010b; Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2011b))

| Region | Biodiesel demand | Biodiesel production | Balance |
|---|---|---|---|
| North | 243,058 | 93,880 | -149,178 |
| Northeast | 385,987 | 186,297 | -199,690 |
| Centre-West | 281,176 | 1,018,301 | 737,125 |
| Southeast | 1,078,377 | 423,123 | -655,254 |
| South | 473,354 | 675,668 | 202,314 |
| Brazil | 2,461,952 | 2,397,270 | -64,682 |

Table 63 – Capital costs for the construction of a 38 million litres biodiesel facility in the United States (Haas et al. 2006)

| Category | Total Costs (USD) |
|---|---|
| Storage facilities | 1 047 000 |
| Process equipment | 2 166 000 |
| Utility equipment | 403 000 |
| Total equipment cost | 3 616 000 |
| Installation costs (200 % of equipment costs) | 7 232 000 |
| Rail siding and miscellaneous improvements | 500 000 |
| Total costs | 11 348 000 |

Table 64 – Annual capital costs of a 38 million litres biodiesel facility for a repayment time of ten years (Haas et al. 2006)

| Costs | Annual cost (USD) | USD/litre biodiesel |
|---|---|---|
| General and administration (0.5% of annually capital costs) | 56740 | 0.001 |
| Property taxes (0.1% of annually capital costs) | 11348 | 0.000 |
| Property insurance (0.5% of annually capital costs) | 56740 | 0.001 |
| Depreciation (10% of annually capital costs) | 1134800 | 0.030 |
| Total annual capital related costs | 1259628 | 0.033 |

Table 65 – Overview of consumption of raw material for 1 000 kg of biodiesel

| Type | Material | Lurgi 2007 | Haas et al. 2006 | Unit |
|---|---|---|---|---|
| Feedstock | Rapeseed oil (dried, degummed and deacidified) | 1 000 | - | kg |
| | Soybean oil, degummed | - | 1010 | Kg |
| Alcohol | Methanol | 96 | 101 | kg |
| Catalysts | Sodium Methylate 100% $NaOCH_3$ | 5 | 12.6 | kg |
| | Hydrochloric acid (37%) HCl | 10 | 7.2 | kg |
| | Sodium Hydroxide (Caustic soda) NaOH (50%) | 1.5 | 5 | kg |
| | Nitrogen | 1 | - | $Nm^3$ |
| Auxiliaries | Steam | 320 | - | kg |
| | Cooling water | 25 | - | $m^3$ |
| | Electrical Energy | 12 | 30 | kWh |
| | Process water | 20 | 33 | Kg |
| | Natural gas | - | 57 | $m^3$ |

Table 66 – Considered prices for consumption-related input for biodiesel production

| Type | Material | Haas et al. 2006 | Unit |
|---|---|---|---|
| Feedstock | Soy oil | 520 | USD/t |
| Alcohol | Methanol | 286 | USD/t |
| Catalysts | Sodium Methylate 100% NaOCH3 | 980 | USD/t |
| | Hydrochloric acid (37%) HCl | 132 | USD/t |
| | Sodium Hydroxide (Caustic soda) NaOH (50%) | 617 | USD/t |
| | Nitrogen | | |
| Auxiliaries | Steam | | |
| | Cooling water | | |
| | Electrical Energy | 0.05 | USD/kWh |
| | Process water | 0.353 | USD/t |
| | Natural gas | 0.16948 | USD/m³ |
| | Wastewater treatment | 50 000 | USD/a |

Table 67 – Typical consumption-related costs for biodiesel production (Haas et al. 2006)

| Type | Material | Cost | Unit | Volume | Cost/litre Biodiesel | % of consumption related costs |
|---|---|---|---|---|---|---|
| Feedstock | Soy oil | 520 | USD/t | 1.010 | 0.46 | 90.1% |
| Alcohol | Methanol | 286 | USD/t | 0.101 | 0.03 | 5.0% |
| Catalysts | Sodium Methylate 100% NaOCH3 | 980 | USD/t | 0.013 | 0.01 | 2.1% |
| | Hydrochloric acid (37%) HCl | 132 | USD/t | 0.007 | 0.00 | 0.2% |
| | Sodium Hydroxide (Caustic soda) NaOH (50%) | 617 | USD/t | 0.005 | 0.00 | 0.5% |
| | Nitrogen | | | | 0.00 | 0.0% |
| Auxiliaries | Steam | | | | 0.00 | 0.0% |
| | Cooling water | | | | 0.00 | 0.0% |
| | Electrical Energy | 0.05 | USD/kWh | 30.260 | 0.00 | 0.3% |
| | Process water | 0.353 | USD/t | 0.034 | 0.00 | 0.0% |
| | Natural gas | 0.16948 | USD/m³ | 56.858 | 0.01 | 1.7% |
| | Wastewater treatment | 50 000 | USD/a | | 0.00 | 0.3% |
| Subtotal consumption related costs | | | | | 0.51 | 100.0% |

Table 68 – Operation-related costs of a 38 million litres biodiesel plant in the US (Haas et al. 2006)

| Categories | Costs | Annual cost USD/a | Cost/litre biodiesel |
|---|---|---|---|
| Labour | Operating (2 persons/shift) 12.5 USD/h, 8000h/a | 200000 | 0.005 |
| | Maintenance | 45000 | 0.001 |
| | Supervisory | 126000 | 0.003 |
| | Fringe benefits (40% of labour costs) | 148400 | 0.004 |
| Subtotal | | 519400 | 0.014 |
| Supplies | Operating supplies (20% of operating labour costs) | 40000 | 0.001 |
| | Maintenance supplies (1% of annually capital costs) | 113480 | 0.003 |
| Subtotal | | 153480 | 0.004 |
| Total operation-related costs | | 672880 | 0.018 |

Table 69 – International diesel and vegetable oil spot prices in USD/ton (2005-2010) (United States Energy Information Administration 2010b; Companhia Nacional de Abastecimento 2011b; United States Department of Agriculture 2011b)

| Month | Diesel (US, fob, low sulfur) | Soy oil (Brazil, fob) | Cottonseed oil (US, fob) | Sunseed oil (Rotterdam, fob) | Palm oil (Malaysia, fob) | Castor oil (Rotterdam) |
|---|---|---|---|---|---|---|
| Jan-05 | 412 | 451 | 536 | 699 | 367 | 1,117 |
| Feb-05 | 423 | 443 | 558 | 695 | 362 | 1,108 |
| Mar-05 | 487 | 494 | 672 | 714 | 400 | 1,132 |
| Apr-05 | 487 | 485 | 704 | 695 | 397 | 1,111 |
| May-05 | 462 | 462 | 761 | 700 | 395 | 1,081 |
| Jun-05 | 522 | 455 | 767 | 706 | 391 | 1,083 |
| Jul-05 | 518 | 457 | 774 | 708 | 391 | 1,081 |
| Aug-05 | 579 | 451 | 700 | 682 | 386 | 1,048 |
| Sep-05 | 639 | 451 | 713 | 683 | 396 | 994 |
| Oct-05 | 634 | 458 | 827 | 646 | 407 | 932 |
| Nov-05 | 539 | 439 | 824 | 598 | 396 | 900 |
| Dec-05 | 538 | 436 | 700 | 602 | 379 | 920 |
| Jan-06 | 552 | 428 | 699 | 591 | 388 | 923 |
| Feb-06 | 545 | 456 | 647 | 595 | 407 | 930 |
| Mar-06 | 584 | 474 | 649 | 606 | 408 | 969 |
| Apr-06 | 655 | 489 | 601 | 659 | 413 | 961 |

| | | | | | | |
|---|---|---|---|---|---|---|
| May-06 | 664 | 497 | 629 | 679 | 420 | 947 |
| Jun-06 | 659 | 478 | 610 | 666 | 415 | 929 |
| Jul-06 | 682 | 500 | 637 | 647 | 435 | 947 |
| Aug-06 | 694 | 509 | 607 | 666 | 470 | 989 |
| Sep-06 | 553 | 518 | 592 | 669 | 449 | 1,048 |
| Oct-06 | 545 | 544 | 605 | 666 | 450 | 1,129 |
| Nov-06 | 545 | 629 | 666 | 722 | 511 | 1,217 |
| Dec-06 | 563 | 629 | 677 | 730 | 559 | 1,215 |
| Jan-07 | 504 | 620 | 683 | 719 | 569 | 1,215 |
| Feb-07 | 545 | 605 | 721 | 709 | 573 | 1,221 |
| Mar-07 | 583 | 605 | 728 | 713 | 593 | 1,216 |
| Apr-07 | 628 | 645 | 758 | 755 | 684 | 1,307 |
| May-07 | 624 | 637 | 832 | 831 | 770 | 1,307 |
| Jun-07 | 655 | 745 | 882 | 916 | 781 | 1,283 |
| Jul-07 | 661 | 780 | 936 | 999 | 789 | 1,300 |
| Aug-07 | 638 | 810 | 929 | 1,114 | 782 | 1,305 |
| Sep-07 | 702 | 829 | 1,026 | 1,279 | 798 | 1,300 |
| Oct-07 | 733 | 896 | 1,151 | 1,358 | 848 | 1,314 |
| Nov-07 | 834 | 1,020 | 1,402 | 1,401 | 935 | 1,357 |
| Dec-07 | 812 | 1,045 | 1,469 | 1,469 | 948 | 1,409 |
| Jan-08 | 799 | 1,177 | 1,580 | 1,709 | 1,053 | 1,460 |
| Feb-08 | 845 | 1,354 | 1,733 | 1,839 | 1,192 | 1,525 |
| Mar-08 | 986 | 1,346 | 1,740 | 1,863 | 1,291 | 1,641 |
| Apr-08 | 1,040 | 1,320 | 1,758 | 1,838 | 1,247 | 1,665 |
| May-08 | 1,170 | 1,322 | 1,824 | 1,962 | 1,250 | 1,661 |
| Jun-08 | 1,201 | 1,382 | 1,930 | 2,045 | 1,199 | 1,655 |
| Jul-08 | 1,180 | 1,326 | 1,897 | 1,692 | 1,115 | 1,756 |
| Aug-08 | 1,001 | 1,110 | 1,599 | 1,319 | 879 | 1,844 |
| Sep-08 | 931 | 987 | 1,377 | 1,176 | 743 | 1,763 |
| Oct-08 | 717 | 769 | 1,024 | 950 | 564 | 1,589 |
| Nov-08 | 580 | 698 | 824 | 835 | 489 | 1,572 |
| Dec-08 | 438 | 627 | 725 | 759 | 511 | 1,502 |
| Jan-09 | 456 | 700 | 787 | 817 | 566 | 1,306 |
| Feb-09 | 399 | 665 | 732 | 805 | 577 | 1,207 |
| Mar-09 | 400 | 655 | 719 | 757 | 595 | 1,130 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Apr-09 | 425 | 762 | 824 | 843 | 716 | 1,234 |
| May-09 | 462 | 847 | 880 | 941 | 799 | 1,164 |
| Jun-09 | 549 | 832 | 854 | 907 | 732 | 1,178 |
| Jul-09 | 519 | 751 | 806 | 804 | 647 | 1,244 |
| Aug-09 | 589 | 814 | 863 | 820 | 719 | 1,261 |
| Sep-09 | 545 | 759 | 803 | 809 | 675 | 1,403 |
| Oct-09 | 607 | 802 | 836 | 846 | 663 | 1,401 |
| Nov-09 | 618 | 853 | 897 | 921 | 703 | 1,394 |
| Oct-09 | 614 | 857 | 913 | 986 | 766 | 1,405 |
| Jan-10 | 639 | 845 | 860 | 969 | 774 | 1,571 |
| Feb-10 | 621 | 840 | 863 | 948 | 778 | 1,582 |
| Mar-10 | 664 | 820 | 879 | 949 | 809 | 1,575 |
| Apr-10 | 701 | 817 | 854 | 924 | 811 | 1,575 |
| May-10 | 649 | 820 | 824 | 910 | 798 | - |
| Jun-10 | 641 | 808 | 882 | 889 | 787 | - |

Table 70 – Additional costs due to biodiesel consumption 2006-2010 in Brazil (Giersdorf, based on (Petrobras - Petróleo Brasileiro S.A. 2009; Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2010c; Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2010f; Agência Nacional do Petróleo, Gás Natural e Biocombustíveis 2011a))

| | | Unit | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|
| A | Biodiesel volume sold at auctions | 1,000 litres | 156,250 | 731,250 | 1,040,000 | 1,565,000 | 2,355,000 |
| B | Medium biodiesel price at auctions | USD/litre | 0.86 | 0.91 | 1.28 | 1.14 | 1.23 |
| C=A*B | Biodiesel costs (1,000 USD) | 1,000 USD | 134,713 | 662,843 | 1,335,130 | 1,785,561 | 2,889,515 |
| D | Savings due to tax re-ductions | 1,000 USD | 10,816 | 60,950 | 50,788 | 72,953 | 147,183 |
| E=C-D | Additional costs due to biodiesel | 1,000 USD | 60,306 | 269,185 | 739,396 | 946,507 | 1,375,317 |
| F | Volume of diesel sold (incl. bio- | 1,000 litres | 39,008,397 | 41,558,180 | 44,763,952 | 44,298,463 | 49,239,039 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | diesel share) | | | | | | |
| G | Medium diesel price ex-refinery | USD/litre | 0.45 | 0.51 | 0.58 | 0.54 | 0.64 |
| H=A/F | Biodiesel share on diesel | % | 0.40 | 1.76 | 2.32 | 3.53 | 4.78 |
| I=A*0.9 | Substituted diesel | 1,000 litres | 140,625 | 658,125 | 936,000 | 1,408,500 | 2,119,500 |
| K=(F-A+I)*G | Theoretical diesel costs for fuel equivalent | 1,000 USD | 17,632,603 | 20,972,291 | 26,001,376 | 24,009,365 | 31,605,833 |
| L=(K+E)/K | Prices due to biodiesel blend | % | 100.3 | 101.3 | 102.8 | 103.9 | 104.4 |

## Figures

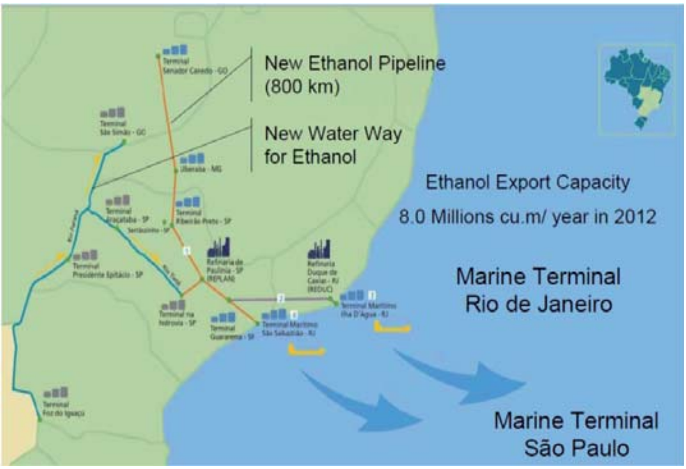


Figure 36 – Petrobras ethanol pipeline project (Luther Moreira 2007)

## Brief summary of main results

Brazilian ethanol support policies changed during the last thirty years, but there is also some continuity. While competitiveness of ethanol was regulated directly by price controls of sugarcane, sugar, ethanol and gasoline during *PROALCOOL*, prices are not regulated anymore. But the mandatory blending of anhydrous ethanol with gasoline continues to be a very important support policy. Other public support policies (e.g. public credit lines for ethanol plants with low interest rates, reduced taxation of hydrated ethanol compared to gasoline, reduced taxation of flexible-fuel vehicles) still shape the sector and promote the demand for ethanol fuel. Since biodiesel is not used as a neat fuel, differentiated tax treatment is not as important as in the case of ethanol. But other support policies (e.g. credit guarantees, mandatory blending, and several programmes for R&D in biodiesel feedstock cultivation and production technologies) are quite similar to those of the ethanol sector. But the social seal and the biodiesel auctions are a peculiarity of the biodiesel sector and a result of the social objectives of the biodiesel programme. Brazil is the largest producer of sugarcane derived products worldwide and ethanol production is expanding rapidly in the Central-West region. Considering the world market ratio of international sugar and gasoline prices in the past years, sugar would have been the more feasible option for the producers theoretically for most of the time. At the domestic market, the competitiveness of ethanol compared to gasoline as a neat fuel at petrol stations depends on the region and the taxation. In the most important production state, the state of São Paulo, the competitiveness of ethanol is reached via a lower excise tax (12% for hydrated ethanol compared to gasoline). Tax losses for São Paulo state due to this lower excise tax and due to lower federal social security contributions amounted to 1.6 billion USD in 2008, representing one fourth of theoretical tax revenues with fuels for spark ignition engines in this state. Tax losses due to reduced taxation of FFV (flexible-fuel vehicles) amounted to 294 million USD in 2008 for Brazil. But since absolute revenues from taxes on fuels for spark ignition engines and on passenger cars increased in Brazil in the past years, these tax losses did not attract any attention or at least were not being discussed controversially. Increasing passengar car sales and increasing fuel consumption show that FFV are not only substituting gasoline cars but contributing to the increasing overall light vehicle fleet in Brazil. Thus, ethanol has become a complementary energy carrier to gasoline rather than a substitute. This raises the question about the effectivity of ethanol fuel as a tool to mitigate greenhouse gas emissions and the justification of the support policies.

In the biodiesel sector, large biodiesel production capacities were installed in Brazil in the last years and the demand for biodiesel caused by the 5% mandatory blend could be met already in 2010. Between 70% and 90% of the biodiesel is produced from soyoil and since the soy processing industry in Brazil has large idle capacities the vegetable oil demand could be supplied rapidly. Biodiesel production costs mainly depend on the feedstock costs and since all vegetable oils used for biodiesel production are internationally traded commodities, the biodiesel production costs follow the volatility of international vegetable oil prices. Considering the high international vegetable oil prices in the past years, the comercialisation of vegetable oil would have been the more feasible option for the biodiesel producers theoretically for most of the time, despite increasing diesel fuel prices. But since biodiesel is rarely exported and not offered as neat fuel, the world market ratio and the competitiveness against fossil diesel only play a minor role compared to the situation in the ethanol sector. The market volume as well as the prices are set by the government. If biodiesel producers shall be remunerated adequately in the biodiesel auctions, international prices of the oilseed commodities have to be considered and this probably causes higher prices for biodiesel compared to fossil diesel. This means that additional costs for biodiesel – the fuel for the public passenger and goods transport – probably will be passed to end consumers in terms of higher diesel fuel prices. However this hypothesis could not be validated in the thesis due to methodological difficulties. In the case of ethanol – the fuel for the individual transport – the costs in terms of tax losses are passed on to the taxpayers by contrast.

The analysis of the main actors revealed that there exist three advocacy coalitions in the ethanol policy arena. The "Ethanol Social and Environmental Coalition" assembling the *Ministério do Meio Ambiente, dos Recursos Hídricos e da Amazônia Legal* (Ministry of Environment, Water Resources and Legal Amazon)*, WWF Brasil*, *Conservação Internacional* (Conservation International)*, Comissão Pastoral da Terra* (Pastoral Land Commission)*, Movimento dos Trabalhadores Rurais sem Terra* (Movement of the Landless Rural Workers)*,* and the *Rede Social de Justiça e Direitos Humanos* (Social Network of Justice and Human Rights) emphasises the role of ethanol as a potential threat to biodiversity and the advancement of the Agrarian Reform. But the actors of this coalition are marginalised within the policy arena and do not manage to influence important political discussions and decisions. The other two coalitions rather have different opinions of the importance of ethanol fuel in Brazilian energy system than antagonistic beliefs and policy demands. The "Ethanol Expansion Coalition" assembling the *Ministério da Agricultura, Pecuária e Abastecimento* (Ministry of Agriculture, Livestock and Food Supply), *Ministério do Desenvolvimento, Indústria e Comércio Exterior (*Ministry of Development, Industry and External Trade), *Congresso Nacional* (National Congress), *Presidência da República/Casa Civil*, *UNICA* (Union of the Sugarcane Industry), and Dedini considers ethanol fuel an important agricultural product and asks for long-term support policies necessary to expand ethanol production and consumption. The "Control Intensification Coalition" consisting of the *Ministério de Minas e Energia*, (Ministry of Mining and Energy), *Agência Nacional do Petróleo, Gás Natural e Biocombustíveis* (*ANP* - National Agency for Petroleum, Natural Gas and Biofuels), *Sindicato Nacional das Empresas Distribuidoras de Combustíveis e de Lubrificantes* (*SINDICOM* - National Association of the Fuel and Lubricant Distribution Companies), Petrobras, and *Associação Nacional dos Fabricantes de Veículos Automotores (ANFAVEA* – National Association of the Car Manufacturers) considers ethanol an important energy carrier and stresses the importance to guarantee the quality of the ethanol fuel. The policy problem of the quality of the ethanol fuel divides the two coalitions and some minor changes in control of ethanol commercialisation are being implemented. The tax incentives – as the main support policy - are not really questioned due to a broad consensus on the importance and the beneficial impacts of ethanol production and consumption in Brazil.

Within the biodiesel policy arena, again three coalitions could be identified. The "Biodiesel Social Development Coalition" aggregates the *Ministério do Desenvolvimento Agrário* (*MDA* - Ministry of Agrarian Development), the *Presidência da República/Casa Civil*, the *Ministério de Minas e Energia*, the *Congresso Nacional*, the companies Petrobras and Brasil Ecodiesel and *Confederação Nacional dos Trabalhadores na Agricultura* (*CONTAG* - National Confederation of the Agricultural Workers) which share the perspective that biodiesel production can promote social development and that regulations are needed for the integration of small farmers into the biodiesel value chain. The "Biodiesel Agribusiness Coalition" aggregates the *Ministério da Agricultura, Pecuária e Abastecimento*, the association of the biodiesel producers *União Brasileira do Biodiesel* (*UBRABIO* – Brazilian Biodiesel Union) and the plant manufacturer Dedini which share the perspective that biodiesel can help to promote the development of the oilseeds and more specifically the soyoil sector in Brazil. And finally the "Biodiesel Technology and Quality Control Coalition" assembles the *Ministério da Ciência e Tecnologia* (*MCT* - Ministry of Science and Technology), the regulatory agency *ANP*, the association of the distribution companies *SINDICOM* and the association of the car manufacturers *ANFAVEA* which all consider biodiesel an important energy carrier that needs strong regulations to guarantee the quality of the biodiesel. With regard to the policy problem of the introduction of the new fuel biodiesel into the market, the "Biodiesel Social Development Coalition" is cautious with a rapid introduction of the mandatory blend since it believes that a fast implementation of the mandatory blend would favour well developed value chains like the soy sector. Consequently, the “Biodiesel Agribusiness Coalition” favours the rapid introduction and increase of the mandatory blend for the development of a large biodiesel demand as an alternative market for the processed soyoil. The “Biodiesel Technology and Quality Control Coalition” asks for a slow implementation of the mandatory blend and the realisation of engine tests to improve data basis for evaluation of the impacts on the engines. As the main policy output, a mandatory blend starting already in 2008 is introduced by the *Congresso Nacional*, but the “Biodiesel Social Development Coalition” uses the mandatory blend of B2 and the anticipation of B5 to guarantee a market share for biodiesel producers holding the social seal – a successful example for policy learning of a coalition through a change in secondary aspects. With regard to the policy problem of the higher costs for biodiesel compared to diesel fuel, the “Biodiesel Social Development Coalition” asks for differentiated tax reductions for biodiesel and this is implemented by the president and left unchanged when the provisory measure N° 227 (06/12/2004) is transformed into law N° 11.116 (18/05/2005) by the *Congresso Nacional*. The policy problem of the biodiesel fuel quality is the main concern of the “Biodiesel Technology and Quality Control Coalition” which asks for the rapid definition of biodiesel standards. But since the “Biodiesel Social Development Coalition” fears that rigid biodiesel standards may exclude the use of feedstocks that are primarily produced by small farmers, many treshold values for parameters are only defined later during the implementation of the biodiesel programme.

By analysing the main ethanol and biodiesel policies and by realising and interpreting the expert interviews, the formulation and the implementation of the main policies could be explained by the positions and interactions of the most important policy actors in the two policy arenas. In the ethanol policy arena there is a broad consensus due to increasing ethanol production, increasing FFV sales and increasing tax revenues, and the structure of the actors is relatively homogeneous since ethanol production is only based on sugarcane concentrated in the Centre-South region and especially São Paulo. In the biodiesel policy arena by contrast, the discussions about the mandatory blend, the taxation of biodiesel and fossil diesel and the biodiesel standard reflect North vs. South and Family Agriculture vs. Agribussines cleavages. Despite the predominance of soybeans in Brazilian oilseed production, the policies aim at promoting other feedstock and these contribute considerably to biodiesel production. This example proves that while general conditions like climate, agricultural structure, and production technologies may favour the use of specific biofuel feedstocks, the main patterns of biofuel production development are not predetermined by such factors but also the result of the political interactions and decisions analysed in this thesis. The various positive and negative impacts of biofuel production in Brazil could not be analysed in detail in this thesis. But the results show that if similar biofuel programmes shall be adopted in other countries, the specific political-regulatory framework of these countries has to be considered as well, since this will also decide upon the distribution of the benefits and costs and the acceptance of these programmes.

## Kurzfassung der Ergebnisse

Die Politiken zur Förderung der Ethanolproduktion haben sich in Brasilien in den vergangenen 30 Jahren verändert, es ist jedoch auch eine Kontinuität zu erkennen. Während des Alkoholprogramms *PROALCOOL* wurde die Wettbewerbsfähigkeit von Ethanol u.a. durch die staatliche Festsetzung der Zuckerrohr-, Zucker-, Ethanol- und Benzinpreise direkt reguliert. Diese direkte Preisregulierung gibt es zwar nicht mehr, aber der Beimischungszwang von anhydriertem Ethanol zum Benzin stellt weiterhin einen wichtigen Fördermechanismus dar. Auch die öffentlichen Kreditlinien mit niedrigen Zinssätzen für Ethanolanlagen, die geringere Besteuerung von hydriertem Ethanol im Vergleich zu Benzin, sowie die reduzierten Steuersätze für Flexible-Fuel-Fahrzeuge fördern die Nachfrage nach Ethanol. Da Biodiesel nicht als Reinkraftstoff genutzt wird, spielen Steuerreduktionen nur eine geringer Rolle. Andere Förderpolitiken (Kreditgarantien, Beimischungszwang und verschiedene Programme zur Forschung und Entwicklung des Rohstoffanbaus und der Produktionstechnologien) sind denen im Ethanolsektor sehr ähnlich. Lediglich das Sozialsiegel und die Auktionen sind eine Besonderheit des Biodieselsektors und Ergebnis der sozialen Ziele des Biodieselprogramms.

Brasilien ist der größte Produzent von Zuckerrohrprodukten und die Ethanolproduktion expandiert vor allem in der Großregion Zentrum-West. Aufgrund der Weltmarktrationalität der internationalen Zucker- und Benzinpreise wäre die Produktion bzw. der Export von Zucker die überwiegende Zeit die ökonomisch attraktivere Option gewesen. Auf dem Binnenmarkt ist Ethanol gegenüber Benzin nicht einmal in dem Bundesstaat São Paulo ohne Steuervorteile wettbewerbsfähig. In diesem Bundesstaat, der für über die Hälfte der brasiliansichen Ethanolproduktion verantwortlich ist, wird die Wettbewerbsfähigkeit durch einen niedrigeren Satz der Verbrauchssteuer (12% für hydriertes Ethanol gegenüber 25% für Benzin) gefördert. Die Steuerverluste aufgrund der geringeren Verbrauchssteuer und die bundesweit niedrigeren Sozialabgaben auf Ethanol als Reinkraftstoff beliefen sich allein für den Bundesstaat São Paulo auf 1,6 Milliarden USD im Jahr 2008 und damit auf ein Viertel der möglichen theoretischen Einnahmen aus der Besteuerung von Ottokraftstoffen. Die entgangenen Steuereinnahmen für ganz Brasilien aufgrund einer geringeren Steuerlast für Flexible-Fuel-Fahrzeuge (FFV) beliefen sich im selben Jahr auf 294 Millionen USD. Da jedoch die absoluten Steuereinnahmen für Ottokraftstoffe in São Paulo und für die Steuer auf Personenwagen in Brasilien in den vergangenen Jahren zunahmen, fallen diese Steuermindereinnahmen nicht weiter auf oder werden zumindest nicht kritisch diskutiert. Die steigenden Verkaufszahlen für Pkws und der steigende Kraftstoffverbrauch zeigen, dass FFV nicht bloß Benzin-Pkws ersetzen, sondern zu einem Anstieg der leichten Nutzfahrzeuge insgesamt beitragen und dass Ethanol eher einen Beitrag zur wachsenden Automobilität und zur Deckung des steigenden Energiebedarfs leistet, als dass es die Nachfrage nach Benzin ersetzt. Dies stellt die Effektivität von Ethanol als Instrument zur Treibhausgasminderung und damit die Begründung der Förderpolitiken in Frage.

Im Biodieselsektor konnten innerhalb der vergangenen Jahre große Produktionskapazitäten aufgebaut und die durch die Beimischungspflicht von 5% erzeugte Nachfrage nach Biodiesel bereits 2010 gedeckt werden. Zwischen 70% und 90% des Biodiesels werden aus Sojaöl hergestellt und da die sojaverarbeitende Industrie in Brasilien über große Überschusskapazitäten verfügt, konnten die Pflanzenölmengen kurzfristig bereitgestellt werden. Die Produktionskosten für Biodiesel hängen hauptsächlich von den Rohstoffkosten ab und da alle Pflanzenöle, die für die Biodieselproduktion genutzt werden, international gehandelt werden, folgen die Biodieselproduktionskosten der Volatilität der Weltmarktpreise für Pflanzenöle. Angesichts hoher Weltmarktpreise für Pflanzenöle wäre trotz teils steigender Dieselpreise in den letzten Jahren der Verkauf von Pflanzenöl für die Biodieselproduzenten meist die theoretisch ökonomisch vorteilhaftere Variante gewesen. Da jedoch Biodiesel kaum exportiert und nicht als Reinkraftstoff angeboten wird, spielen die Weltmarktrationalität ebenso wie die direkte Wettbewerbsfähigkeit gegenüber fossilem Diesel nur eine geringe Rolle. Das Marktvolumen wie auch die Preise für Biodiesel werden von der Regierung festgelegt. Wenn die Biodieselproduzenten angemessen vergütet werden sollen bei den Biodieselauktionen, dann fließen die Weltmarktpreise für die Ölsaaten und Pflanzenöle entsprechend in die Kalkulation ein, so dass sich höhere Preise für den Biodiesel als für den Diesel ergeben. Dies bedeutet, dass die Mehrkosten für Biodiesel – den Kraftstoff für den öffentlichen Personen- und Güterverkehr – sehr wahrscheinlich in Form höherer Dieselkraftstoffpreise auf die Endverbraucher abgewälzt werden. Allerdings ist es methodisch sehr schwierig, dies zu beweisen, so dass dies in der vorliegenden Arbeit nicht geleistet werden konnte. Im Fall von Ethanol hingegen – dem Kraftstoff für den Individualverkehr – werden die Mehrkosten in Form von Steuerverlusten von den Steuerzahlern getragen.

Die Analyse der wichtigsten politischen Akteure ergab, dass es drei Advocacy-Koalitionen in der Ethanolpolitikarena gibt. Die Koalition „Ethanol - Soziales und Umwelt“, die das *Ministério do Meio Ambiente, dos Recursos Hídricos e da Amazônia Legal* (Ministerium für Umwelt, Wasserressourcen und Amazonien), *WWF Brasil*, *Conservação Internacional* (Conservation International), *Comissão Pastoral da Terra* (Landpastorale), *Movimento dos Trabalhadores Rurais sem Terra* (Bewegung der Landlosen), and the *Rede Social de Justiça e Direitos Humanos* (Soziales Netzwerk für Gerechtigkeit und Menschenrechte) umfasst, betont die Rolle von Ethanol als einer möglichen Bedrohung für die Biodiversität und die Agrarreform. Aber die Akteure dieser Koalition sind marginalisiert innerhalb der Politikarena und üben geringen Einfluss auf die wichtigen politischen Diskussionen und Entscheidungen aus. Die anderen beiden Koalitionen haben eher unterschiedliche Perspektiven bezüglich der Bedeutung von Ethanol im brasilianischen Energiesystem als antagonistische Wertesysteme und Politikforderungen. Die Koalition „Expansion des Ethanols“, die das *Ministério da Agricultura, Pecuária e Abastecimento* (Ministerium für Landwirtschaft, Viehzucht und Versorgung), *Ministério do Desenvolvimento, Indústria e Comércio Exterior* (Ministerium für Entwicklung, Industrie und Außenhandel), *Congresso Nacional* (Nationalkongress), *Presidência da República/Casa Civil* (Staatspräsident), *UNICA* (Verband der Zucker- und Ethanolproduzenten) und Dedini (Anlagenhersteller) vereint, betrachtet Ethanol als wichtiges landwirtschaftliches Produkt und fordert langfristige Förderpolitiken für den Ausbau der Ethanolproduktion bzw. des –verbrauchs. Die Koalition „Verstärkung der Kontrolle des Ethanols“ bestehend aus dem *Ministério de Minas e Energia* (Ministerium für Bergbau und Energie), *ANP* (Nationale Mineralöl-, Gas- und Biokraftstoffagentur), *SINDICOM* (Verband der Mineralöl- und Schmierstoffunternehmen), Petrobras (Staatliches Mineralölunternehmen) und *ANFAVEA* (Nationaler Verband der Automobilindustrie), betont hingegen die Rolle von Ethanol als wichtigem Energieträger und fordert vor allem, die Qualität desselben sicherzustellen. Das Politikproblem der Qualität des Ethanolkraftstoffs unterscheidet die Koalitionen voneinander und kleinere Änderungen bei der Kontrolle der Ethanolkommerzialisierung werden durchgeführt. Die Steueranreize für Ethanol werden jedoch nicht in Frage gestellt, da in Brasilien Konsens herrscht über die Bedeutung und die Vorteile der Ethanolproduktion und des -verbrauchs.

Innerhalb der Biodieselpolitikarena konnten drei Koalitionen identifiziert werden. Die Koalition „Biodiesel für die soziale Entwicklung“ vereint das *Ministério de Desenvolvimento Agrário* (Ministerium für Ländliche Entwicklung), den Staatspräsidenten, das *Ministério de Minas e Energia*, den *Congresso Nacional*, die Unternehmen Petrobras und Brasil Ecodiesel und die Landarbeitergewerkschaft *CONTAG*, die gemeinsam die Ansicht vertreten, dass die Biodieselproduktion soziale Entwicklung befördern kann und dass Maßnahmen nötig sind, um die Kleinbauern in die Wertschöpfungskette zu integrieren. Die Koalition “Biodiesel als Agribusiness” vereint das *Ministério da Agricultura, Pecuária e Abastecimento*, den Verband der Biodieselproduzenten *UBRABIO* und den Anlagenhersteller Dedini, die alle den Standpunkt vertreten, dass Biodiesel die Entwicklung des Ölsaaten- und insbesondere des Sojasektors in Brasilien fördern kann. Und schließlich verbindet die Koalition „Technologie und Qualitätskontrolle des Biodiesels“ mit dem *Ministério da Ciência e Tecnologia* (Ministerium für Wissenschaft und Technologie), der Aufsichtsbehörde *ANP*, *SINDICOM* und *ANFAVEA* Akteure, die Biodiesel als wichtigen Energieträger betrachten, der einer strengen Regulierung bedarf, um die Qualität sicherzustellen. Beim Politikproblem der Einführung des neuen Kraftstoffs Biodiesel in den Markt ist die Koalition „Biodiesel als soziale Entwicklung“ vorsichtig bezüglich der schnellen Einführung einer verpflichtenden Beimischung, da sie befürchtet, dies könne die gut strukturierte sojaverarbeitende industrie begünstigen. Die “Biodiesel-Agribusiness-Koalition” hingegen befürwortet die schnelle Einführung und einen schnellen Anstieg der Beimischungspflicht, um die Biodieselnachfrage und damit einen alternativen Absatzmarkt für das verarbeitete Sojaöl zu fördern. Die Koalition „Technologie und Qualitätskontrolle des Biodiesels“ fordert eine langsame Einführung der Beimischungspflicht und Motorentests um die Datenbasis zur Bewertung der Auswirkungen auf die Motoren besser bewerten zu können. Als Politikergebnis wird vom *Congresso Nacional* eine verpflichtende Beimischung ab 2008 eingeführt. Allerdings weiß die Koalition „Biodiesel als soziale Entwicklung“ die Beimischungspflicht zu nutzen, um einen garantierten Absatzmarkt für Biodieselproduzenten, die im Besitz des Sozialsiegels sind, zu etablieren – ein erfolgreiches Beispiel des *policy learning* durch eine Änderung der sekundären Aspekte einer Koalition. Beim Politikproblem der höheren Kosten für Biodiesel im Vergleich zu Dieselkraftstoff fordert die Koalition „Biodiesel als soziale Entwicklung“ differenzierte Steuervergünstigungen für Biodiesel, und dies wird vom Staatspräsidenten mit der provisorischen Maßnahme N° 227 (06/12/2004), die vom *Congresso Nacional* ohne Änderungen in das Gesetz N° 11.116 (18/05/2005) umgewandelt wird, auch umgesetzt. Das Politikproblem der Biodieselkraftstoffqualität ist die Hauptsorge der Koalition „Biodiesel Technologie und Qualitätskontrolle“, die die schnelle Definition von Parametern des Biodieselstandards fordert. Aber da die Koalition „Biodiesel als soziale Entwicklung“ befürchtet, strenge Biodieselstandards könnten Rohstoffe von der Biodieselproduktion ausschließen, die hauptsächlich von Kleinbauern kultiviert werden, werden für viele Parameter erst später im Laufe des Biodieselprogramms Grenzwerte definiert.

Mittels der Analyse der wichtigsten Ethanol- und Biodieselpolitiken und der Durchführung und Interpretation von Experteninterviews konnten die Formulierung und die Implementierung der wichtigsten Politiken durch die Positionen und Interaktionen der wichtigsten Akteure in den jeweiligen Arenen erklärt werden. In der Ethanolpolitikarena herrscht bei den dominanten Akteuren breiter Konsens bezüglich der Vorteile der Ethanolproduktion aufgrund einer Zunahme der Ethanolproduktion, der FFV-Verkaufszahlen und der Steuereinnahmen – auch wenn dabei übersehen wird, dass die Steuereinnahmen ohne die Reduktion für Ethanol noch höher liegen könnten. Da sich die Ethanolproduktion nur auf den Rohstoff Zuckerrohr stützt und sich auf die Großregion Zentrum-Süd und v.a. São Paulo konzentriert, ist die Akteursstruktur relativ homogen. In der Biodieselpolitikarena hingegen spiegeln die Diskussionen über die Beimischungspflicht, die Besteuerung von Biodiesel und fossilem Diesel und die Biodieselnorm die Konfliktlinien Nord- versus Südbrasilien und Kleinbauern versus Agribusiness wider. Trotz der Dominanz der Sojabohnen in der brasilianischen Ölsaatenproduktion zielen die Politiken darauf ab, andere Rohstoffe zu fördern und diese tragen auch bedeutend zur Biodieselproduktion bei. Dies beweist, dass sich aufgrund des Klimas, der Agrarstruktur und der Produktionstechnologien spezifische Rohstoffe für die Biokraftstoffproduktion anbieten können, die Entwicklung der Biokraftstoffproduktion jedoch durch solche Faktoren nicht determiniert wird, sondern auch das Resultat politischer Interaktionen und Entscheidungen ist. Die Ergebnisse der Dissertation verdeutlichen, dass im Falle anderer Länder, die ähnliche Biokraftstoffprogramme adaptieren wollen, eine Analyse des spezifischen politisch-regulatorischen Kontextes nötig ist, da dieser über die Verteilung des Nutzens und der Kosten und die Akzeptanz der Programme entscheidet.

## List of publications (Liste der Vorveröffentlichungen)

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# Publications

## Below other publications of the DBFZ

(The language of the title reflects the language of the publication)

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Methodische Vorgehensweise zur Standortidentifikation und Planung der Biomassebereitstellung für Konversionsanlagen am Beispiel von Bio-SNG-Produktionsanlagen
Author: Michael Seiffert

**DBFZ Report No. 3**
Feinstaubminderung im Betrieb von Scheitholzkaminöfen unter Berücksichtigung der toxikologischen Relevanz
Author: Volker Lenz

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