Oil, Gas and
Biofuels Industry

THE BRAZILIAN OIL, GAS AND BIOFUELS INDUSTRY'S CONTRIBUTION TO THE COUNTRY'S SUSTAINABLE DEVELOPMENT

INDUSTRY MEETING FOR SUSTAINABILITY

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SUMMARY

CNI PRESENTATION

The diversity of the national industry and the significant availability of natural resources reveal excellent opportunities for the sustainable development of Brazil, combining economic growth, social inclusion and environmental conservation. The materialization of concerns related to sustainability in the strategic agenda of enterprises and governments is a reality. Apart from isolated cases of success, the consequences of this attitude are felt in entire sectors of the economy. Further advances are still needed, but the path has already been identified and going back is impossible.

After coordinating an unprecedented critical thinking process on sustainability with 16 industry associations, the National Industry Confederation (CNI) delivers to the Brazilian society a wide range of information on progress, challenges and opportunities yet to come. The results presented here may not portray the significance of the discussion process experienced by the industry in preparing these documents. Developments on the process will be beyond the Rio +20 Conference, and are definitely incorporated on the daily lives of companies.

The subject of sustainability is inserted differently in each of the industrial sectors. However, some elements are common to all. The continuous pursuit for efficiency in use of resources and the need to increase industrial competitiveness are on the agenda of all the sectors. Encouraging innovation and scientific and technological development is strategic on the transition to more sustainable patterns of production.

Strategies to intensify actions coordinated internally in the industrial sectors and with governments and civil society organizations are no less important. The dissemination of sustainable practices by means of the supply chain and incentives for companies to undertake the role of integrated management of the territories are powerful tools.

The sectorial volumes developed by industry associations are valuable contributions to addressing subjects such as sustainability and competitiveness of domestic industry. One of the most representative results of this process will certainly be the strengthening of structured programs of action with a focus on promoting sustainability in the production. These initiatives will act as raw materials so that the industries involved and CNI are able to systematically publish documents presenting the national industry´s developments towards the goals of sustainable production.

The documents presented here are intended to be a valuable contribution to enhance the debate on sustainability. Each of the sectorial associations is to be congratulated for their efforts.

Robson Braga de Andrade
President of the National Confederation of Industry – Brazil

SECTORIAL PRESENTATION

The Brazilian Petroleum, Gas and Biofuels Institute (IBP), in collaboration with other Brazilian industry segments, has elaborated this volume that summaries the advances made over the last 20 years by the industry. The goal has been to make its businesses more sustainable, as well as accentuate the perceived potential and opportunities that have emerged with the maturing of the sustainability theme in the sector.

The conditions of well-being and the ability to produce goods and services in the modern world were based on the abundant supply of energy resources, obtained mainly from the fossil sources of coal and petroleum. In recent decades, for strategic, economic and environmental imperatives, this energy model has been clearly undergoing an evolution, with the progressive incorporation of renewable sources.

Future scenarios suggest that non-OECD countries, including Brazil, will be responsible for most of the additional global energy consumption, due to their economic development expectations. The discovery of the Brazilian Pre-Salt reserves, highlighted by their very significant hydrocarbon volumes, will sustain the country's economic self-sufficiency for several decades.

The successful Brazilian experience with biofuels, with the regular employment of ethanol blends since the thirties, and pure hydrated ethanol since 1979, indicates the importance to improve its supply chain logistics to consolidate biofuels programs.

Thus, it identifies the relevance to integrate the energy and petroleum based derivatives sectors with those of bioenergy, to offer strategic and economic advantages to these industries and society. The oil and gas industry's contribution to sustainable development in Brazil points to significant medium and long term results. The industry is committed to provide the energy to sustain the country's economic growth to meet the current energy demand. It is further committed to produce it through secure, reliable and efficient operations, which are environmentally and socially responsible. The industry reaffirms its commitment to leverage the evolution of other sustainable energy sources to address the climate change risks and other environmental and social impacts – now and in the coming decades. Biofuels are the key elements of this strategy.

João Carlos de Luca
President of IBP

1 INTRODUCTION

1.1 Presentation of the sectoral entity/institution

The Brazilian Petroleum, Gas and Biofuels Institute is a private non-profit organization, founded on November 21, 1957, and today has around 220 member companies. It seeks to promote the development of petroleum, gas and biofuels in Brazil by fostering competitiveness and sustainability, as well as ethical and socially responsible behavior in the industry.

Since 2003, IBP has undergone profound organizational restructuring to ensure the suitability of its services, products and activities for the industry's evolution, which itself has been going through major transformations in Brazil. The main products offered by IBP are the result of intelligence gathered in 60 permanent technical, sectorial or standardization committees and subcommittees. Over 1,500 professionals voluntarily participate and they include executives and industry experts, scientific and academic institutions, government agencies and congener associations. The Institute also promotes a large number of courses and technical events.

1.2 Objectives of the article

Twenty years have passed since Rio 92 was held in Rio de Janeiro and 10 years since the Johannesburg Summit and now the United Nations Organization – UN is organizing a new Conference on the Environment and Sustainable Development. It will be held in June 2012 in Rio de Janeiro with two main themes: (a) the green economy in the context of sustainable development and poverty eradication and (b) the institutional framework for sustainable development.

The UN guiding resolution for Rio +20 indicates the need to encourage the engagement of all stakeholders. In this context, the oil, gas and biofuels industry offers, in this document, their contribution to the sustainability agenda debate.

This document is one fascicle from the various Brazilian industrial segments developed under the leadership and coordination of the Confederação Nacional da Indústria - CNI (National Industries Confederation), addressing its contribution to sustainable development.

This summary records the advances made since 1992 by the Brazilian oil, gas and biofuels industry seeking to make its business more sustainable, as well as the perceived potential and opportunities that emerge with the maturing of the sustainability theme in the sector.

SECTION I

PETROLEUM AND NATURAL GAS

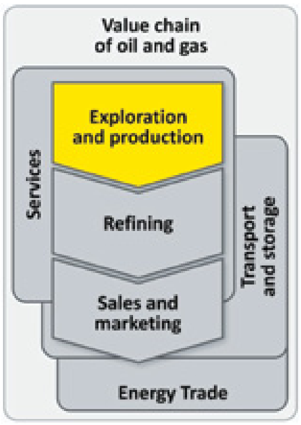
2 THE OIL AND NATURAL GAS INDUSTRY'S ECONOMIC AND SOCIAL-ENVIRONMENTAL CHARACTERIZATION

2.1 Economic Characterization

2.1.1 Description of the industry's production chain

The oil and natural gas industry production chain is extensive and complex. The chart below (Figure 1) provides an overview of the main links in the chain, and the several segments relevant to the overall industry operation.

FIGURE 1. OIL AND NATURAL GAS INDUSTRY VALUE CHAIN

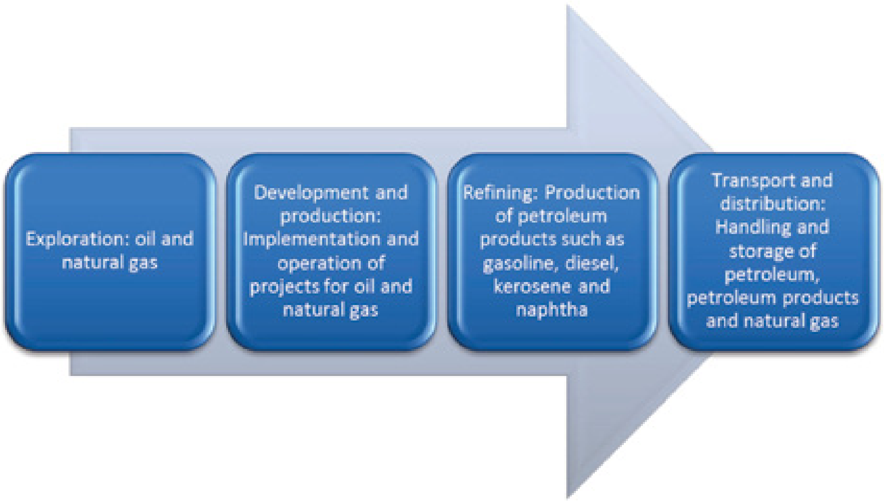


Source: BAIN & COMPANY; TOZZINI FREIRE ADVOGADOS, 2009.

Throughout the entire chain, the industry's activities are responsible for the generation of thousands of direct and indirect jobs throughout the country.

IBP acts on behalf of its members, in the following components of the oil and natural gas production chain (Figure 2):

FIGURE 2. SCOPE OF IBP ACTIVITIES IN THE OIL AND NATURAL GAS PRODUCTION CHAIN

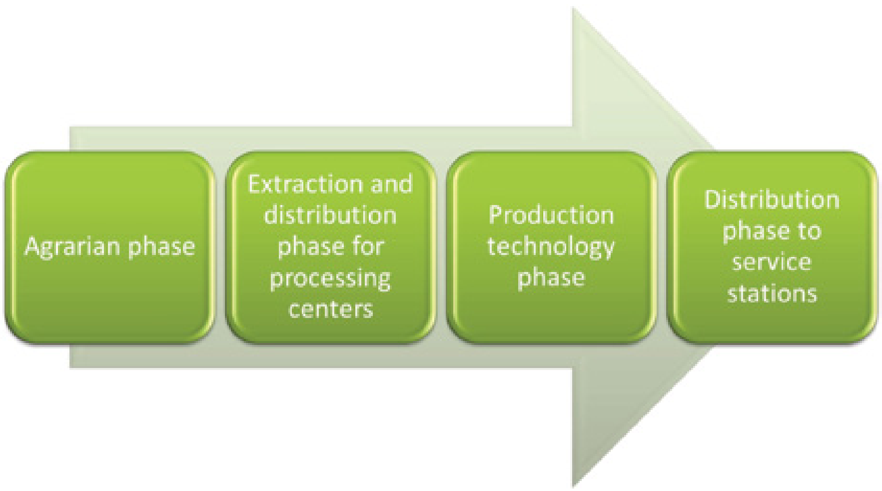


Source: IBP, 2012.

Although IBP also develops activities in the petrochemical segment, this document only covers the components featured in Figure 2. Other segments that interact with the oil, gas and biofuels industry production chain will be addressed by their sectorial organizations, as agreed with CNI.

The main components of the biofuels production chain are:

FIGURE 3. BIOFUELS PRODUCTION CHAIN



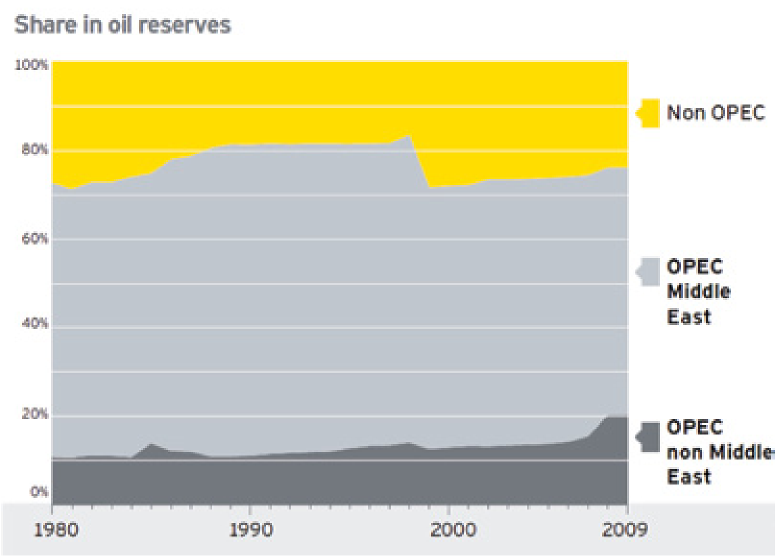
Source: IBP, 2012.

This report does not separately detail each step in the chain, but discusses the overall sugarcane ethanol and biodiesel life cycles. Furthermore, it indicates an economic and socio-environmental short characterization of the agro-industry, highlighting the economic and socio-environmental regulations that impact the industry's business practices geared to sustainable development (particularly between 1992-2011) and the industry's challenges and opportunities on the road to sustainability. Comments and conclusions are presented of a more general character, including observations on the distribution steps and use of biofuels.

2.1.2 Evolution of petroleum and natural gas production

In 2010, the world's proven oil reserves reached 1.38 trillion barrels. How these reserves are distributed is shown in Figure 4 below.

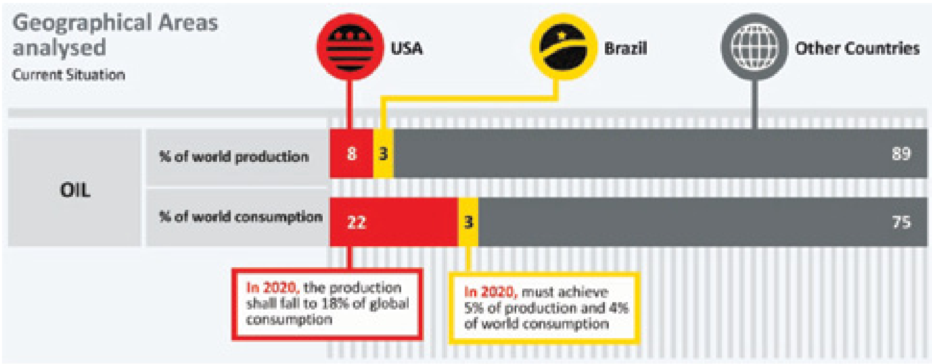
FIGURE 4. THE WORLD'S OIL RESERVES – OPEC MEMBERS AND NON MEMBERS



Source: ERNST & YOUNG TERCO BRASIL, 2011.

The Brazilian participation is relatively small in this major oil and gas producer's context, but it is growing in the non-OPEC segment, as illustrated in Figure 5, as follows:

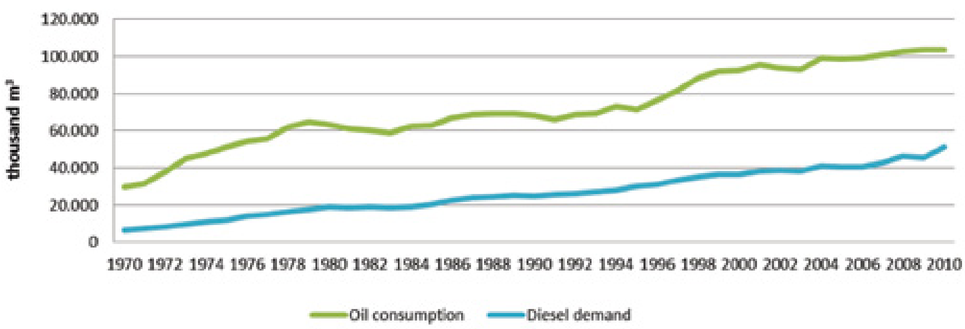
FIGURE 5. BRAZIL'S PARTICIPATION IN GLOBAL PETROLEUM PRODUCTION AND CONSUMPTION, CURRENT AND 2020 FORECAST SITUATION



Source: ERNST & YOUNG TERCO BRASIL, 2011.

Oil consumption in Brazil is essentially determined by domestic demand for diesel, since virtually all public passenger and cargo transport is based on diesel powered vehicles, due to the country's continental dimensions. The close correlation between Brazilian diesel and petroleum consumption can be clearly observed in Figure 6, below.

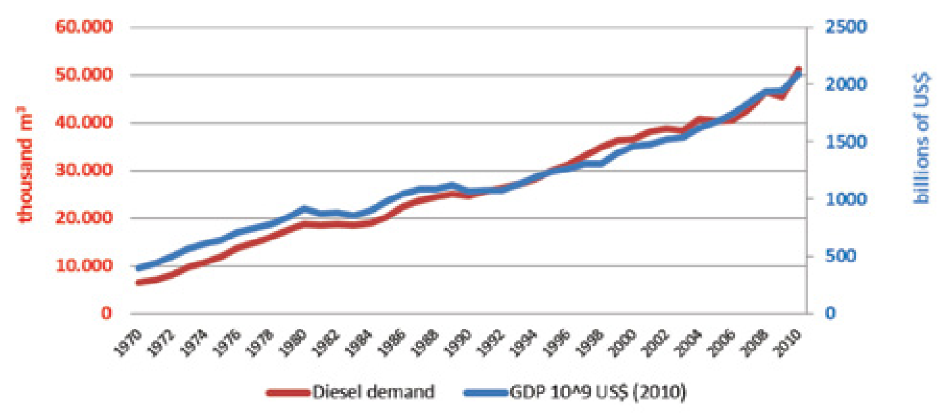
FIGURE 6. BRAZILIAN DIESEL DEMAND AND PETROLEUM CONSUMPTION



Source: EPE, 2011b

Diesel demand, in turn, is directly related to the economic performance: economic growth leads to an increased quantity of cargo and, at the same time, increased passenger movement, based on its own economic dynamism and people's increased income. This relationship is shown in Figure 7 below.

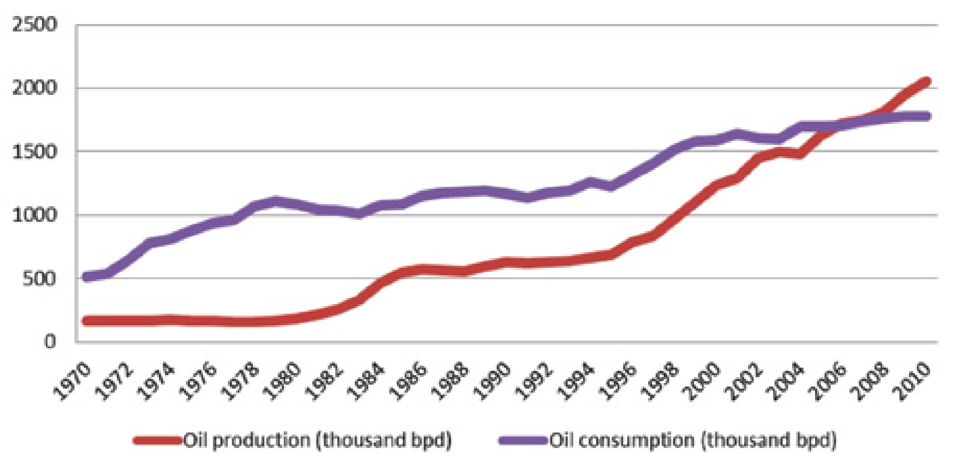
FIGURE 7. BRAZILIAN DIESEL DEMAND X GDP



Source: EPE, 2011b

However, the correlation between Brazilian petroleum production and the macroeconomic variables is less direct. Although increased consumption is a significant factor, it alone does not determine the trajectory of petroleum production evolution. As is shown in Figure 8, below, the Brazilian oil production growth rate over the past few decades was significantly higher than the increased consumption.

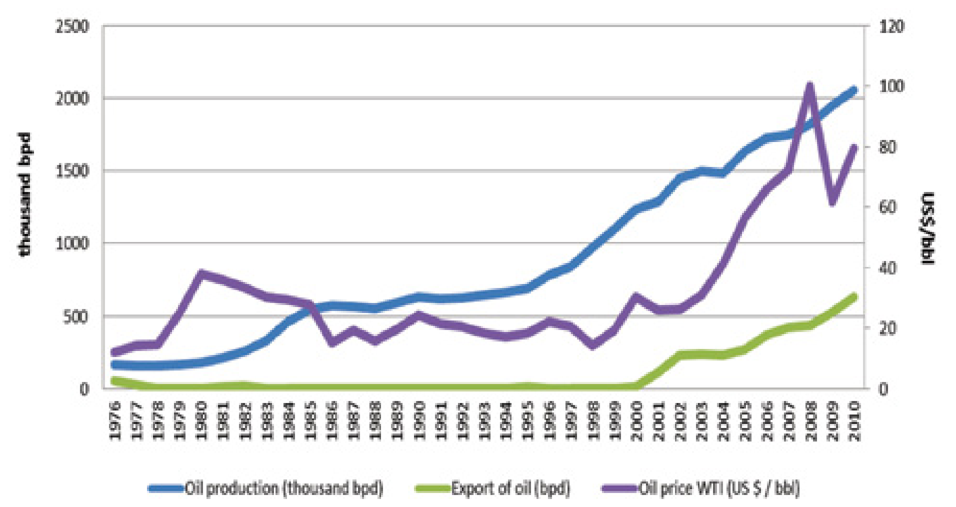
FIGURE 8. BRAZILIAN PETROLEUM PRODUCTION X CONSUMPTION



Source: EPE, 2011b.

Even the international market oil price change does not explain the expansion of domestic production, as shown in Figure 9 below.

FIGURE 9. NATIONAL PETROLEUM PRODUCTION X INTERNATIONAL OIL PRICE



Source: EPE, 2011b

The Brazilian oil production behavior reflects the influence of other variables, strategic or political in nature: the interest to guarantee the security of supply of a key commodity that is largely produced globally in politically and socially unstable regions; the positive impact of the domestic oil production, on virtually all other economic activities and the beneficial effects on the country's balance of trade, stemming from not only the fall in imports but also the possibility to export petroleum. There is a large international oil buying market, which certainly can also represent a major incentive to expand production. Brazilian oil exports have significantly grown over the past decade, which can also be seen in Figure 9, reaching approximately 27% of production in 2010. It should be noted, Brazil still imports light oil to meet the technical specifications of national refineries.

According to National Agency of Petroleum, Natural Gas and Biofuels (ANP) data, in 2011 Brazilian oil production reached 2.2 million barrels of oil per day (bpd), which consolidates the country's self-sufficiency of this commodity, achieved in 2006, as shown in Figure 8. The relationship between the proven reserves and production (R/P) is currently 18 years, which puts Brazil in a comfortable position regarding future resource availability.

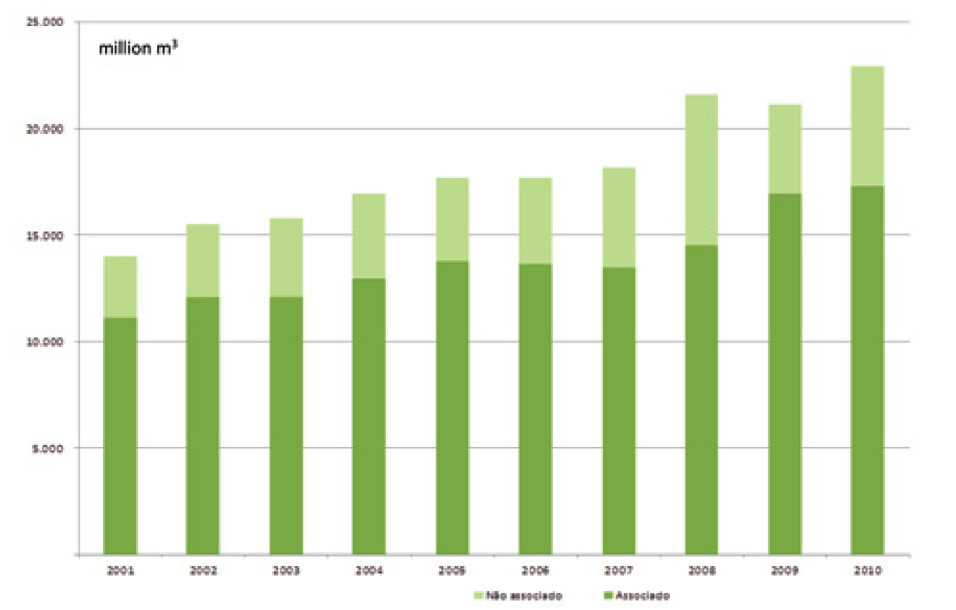
This was achieved through large exploration and production (E&P) development programs that have been executed in recent decades. Brazilian oil production, incipient until the end of the 1970s, reached just over 180 thousand barrels/day in 1980. With the discoveries of off-shore fields in the 1970s, fruit of Petrobras (established 1953) exploratory efforts, national production soared, and by 1985 had reached 590 thousand barrels per day, representing half the domestic oil demand. In the following ten years, production more than doubled and currently the company holds one of the world's most advanced technologies for deep water and ultra-deep water oil production.

According to ANP (2011) data, 94% of the 14.2 billion barrels (2010) proven national oil reserves is located in off-shore fields and the remainder in on-shore fields. This relationship should remain at high levels because of the recent mega Pre-Salt discoveries, which covers much of the country's Southeast and South continental margin regions.

In the case of natural gas, the Brazilian proven reserves are not very significant in global terms. According to Ministry of Mines and Energy (MME) (2011) data, the reserves of 423 billion m^3 in 2010, represented only 0.2 of the world total.

As much of the Brazilian hydrocarbon reserves are located in offshore fields, most of the natural gas produced in Brazil originates from maritime installations. This production has been growing systematically, especially with regard to associated gas, as shown in Figure 10.

FIGURE 10. EVOLUTION OF BRAZILIAN NATURAL GAS PRODUCTION (MILLION M³)



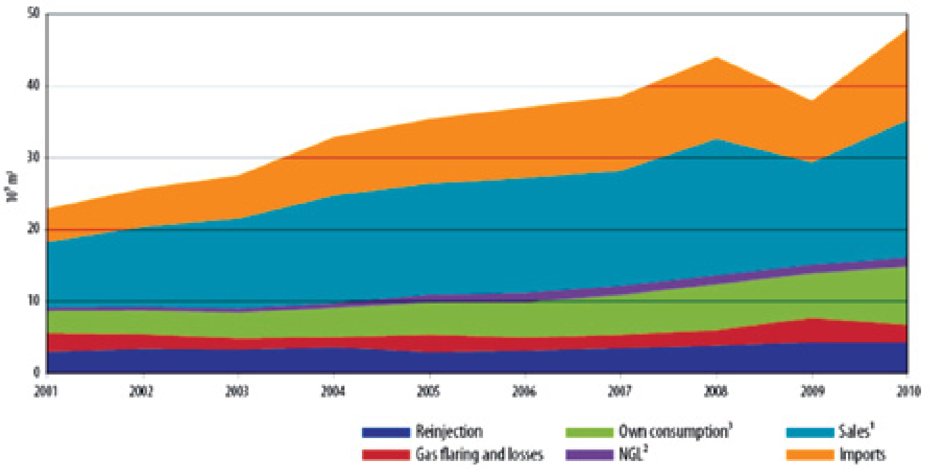
Source: ANP, 2011; BP, 2011.

Brazilian natural gas production behavior reflected a model adopted by most developed countries, with gas use being gradually abandoned during the first half of the twentieth century, and passing to occupy a minor position in national energy matrices. Only following the 70s energy crisis and, above all throughout the 90s, several less industrialized countries critically analyzed the experience of most developed countries and they began to favor natural gas as a strategic power source, encouraging its development and use.

This recent trend is reinforced by the global climate change debate, since natural gas, being a less carbon-intensive fuel, can represent an effective way to mitigate the phenomenon.

The Brazilian natural gas market has grown strongly in recent years, the industrial segment being the most significant portion of the demand. The 2001 electricity supply crisis resulted in bringing the topic of natural gas industry development to the top of the agenda. Natural gas became seen as a more suitable fuel to increase the country's need for short-term electric power generation capacity while providing security against rainfall fluctuations. Nevertheless, the main impetus for natural gas consumption in Brazil occurred with the inauguration of the Bolivia-Brazil gas pipeline in 1999, with an approximately 30 million m³ p/day transport capacity, promoting the increase in gas consumption, as illustrated in Figure 11.

FIGURE 11. EVOLUTION OF NATURAL GAS BALANCE IN BRAZIL – 2001/20107

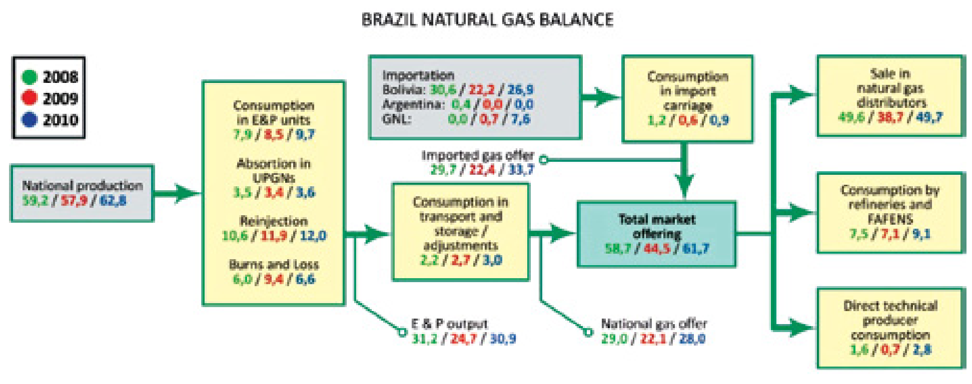


Sources: ANP/SDP; ANP/SCM; Petrobras/Unidade de Negócios de Gás Natural (Table 1.15).
¹Sales to Nitrogenated Fertilizer Plants (Fafen), owned by Petrobras, included. ²Volume of gas absorved in NGPPs (LPG, C_5^+, ethane and propane). ³Refers to Petrobras own consumption in natural gas production, refining, electricy generation and processing and transferring areas.

Source: ANP, 2011.

According to Ministry of Mines and Energy (MME) data, proven natural gas reserves in 2010 were 423,012 million m³ and the Brazilian average NG production was 62.84 billion m³ a day. Imports totaled an approximate average 34 million m³/day during the same period. The natural gas balance in the country, over the past 3 years, is charted in Figure 12.

FIGURE 12. NATURAL GAS BALANCE OFFERED IN THE COUNTRY (MILLIONS OF M³/DAY)



Source: MME, 2011.

2.1.3 Petroleum refining and Natural Gas processing

The oil currently produced in Brazil is used primarily as a raw material in refineries, where it is processed to obtain various types of derivatives. Brazil occupies ninth place in the world for refining capacity, achieving 2.1 million barrels p/day or 2.3% of world capacity (ANP, 2011).

According to ANP, the 16 national refineries processed 1.8 million barrels of oil per day (659.6 billion barrels a year) in 2010. Of the total petroleum processed, 80.2% was domestic production and the rest imported.

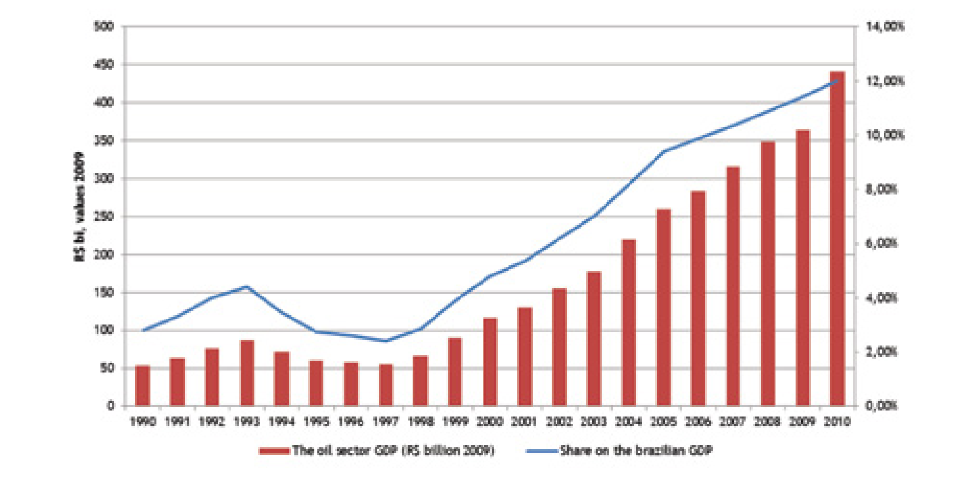
Regarding natural gas, in addition to that transported from Bolivia, Brazil still imports Liquefied Natural Gas-LNG, which is rendered in two regasification plants, one in Guanabara Bay, Rio de Janeiro, with a 14 million m³ p/day capacity, and another in Pecém, Ceará, with a 6 million m³ p/day capacity.

2.1.4 The sector's participation in the Brazilian industrial GDP

The GDP information for the oil and gas industry and the sector's participation in the national GDP during the period 1990 to 2010 GDP is consolidated in Figure 13. As indicated, the oil and gas industry GDP was little more than R$ 50 billion in 1990 increasing to about R$ 440 billion in 2010. The graph also shows the oil sector involvement in the national GDP increased from 3% in 1990 to 12$ in 2010[1], with further growth potential over the next decade.

1 CANELAS, ANDRÉ LUÍS DE SOUZA – "**Evolution of the economic importance of the Oil and Natural Gas Industry in Brazil: Contribution to macroeconomic variables**". [Rio de Janeiro] 2007. 120 p. (COPPE/UFRJ, M.Sc., Energy Planning, 2007).

FIGURE 13. DEVELOPMENT OF THE OIL AND NATURAL GAS INDUSTRY PARTICIPATION IN THE NATIONAL GDP

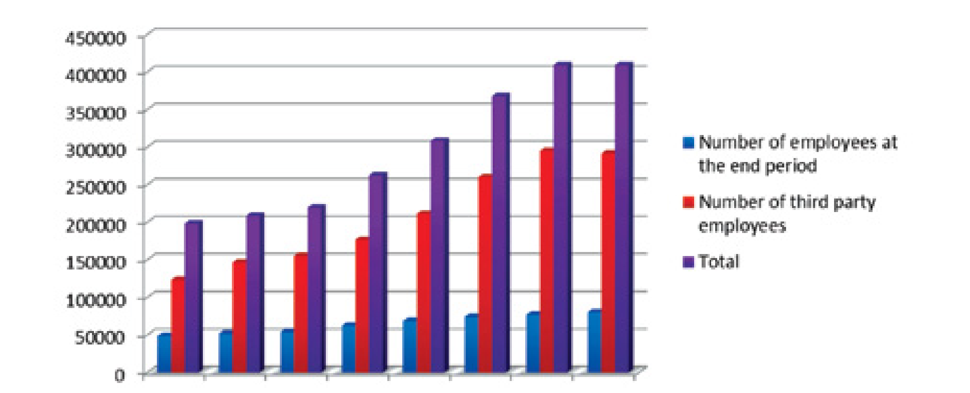


Source: CANELAS, 2007 e IBP, 2011.

2.1.5 Number of jobs generated by the industry

With reference to the available IBP data it is possible to estimate the Brazilian oil and gas industry currently generates about 400,000 direct jobs, the evolution and distribution of which are shown in Figure 14.

FIGURE 14. DIRECT EMPLOYMENT GENERATED BY THE BRAZILIAN OIL AND GAS INDUSTRY



Source: IBP, 2011

2.1.6 Number of E&P enterprises in Brazil

As a result of bidding rounds promoted by ANP since 1999, 62 companies had developed exploratory activities in sedimentary basins by 31/12/2010 (ANP – 2011).

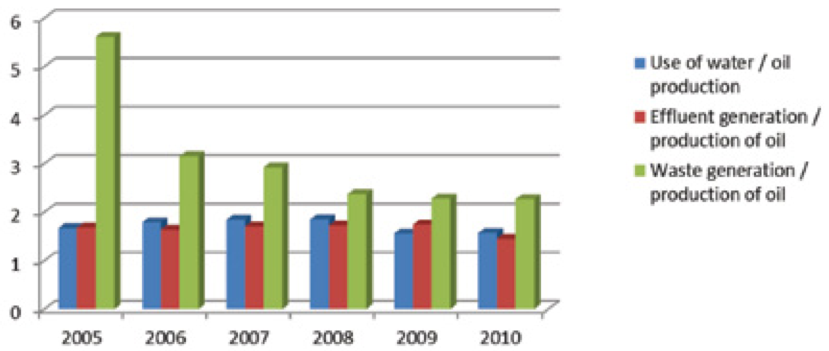
Despite the high number of companies operating in the country, the degree of concentration in production is still very high. According to ANP, in 2010 Petrobras alone was responsible for 93.3% of the oil produced that year, with an average production of 1.92 million bpd. The other companies produced on average 137 thousand bpd.

2.2 Environmental characterization aspects of the oil and natural gas production chain

The oil and gas production chain is very complex and involves a series of stages, each with a potential environmental impact, which varies in nature and magnitude depending on the planned activity and its location. This report provides a brief analysis of the environmental performance development by the industry in Brazil over the last five or six years, focusing on aspects related to water consumption, effluent generation, residues and spills.

The changes in the Brazilian oil and gas industry performance, with regard to the abstraction of water, waste and effluent generation, related to oil production in each period, are shown in Figure 15.

FIGURE 15. THE OIL AND GAS INDUSTRY ENVIRONMENTAL PERFORMANCE INDICATORS FOR (WATER AND EFFLUENTS-M³/10³ M³; WASTE-T/10³ M³)



Source: MAGRINI, 2011.

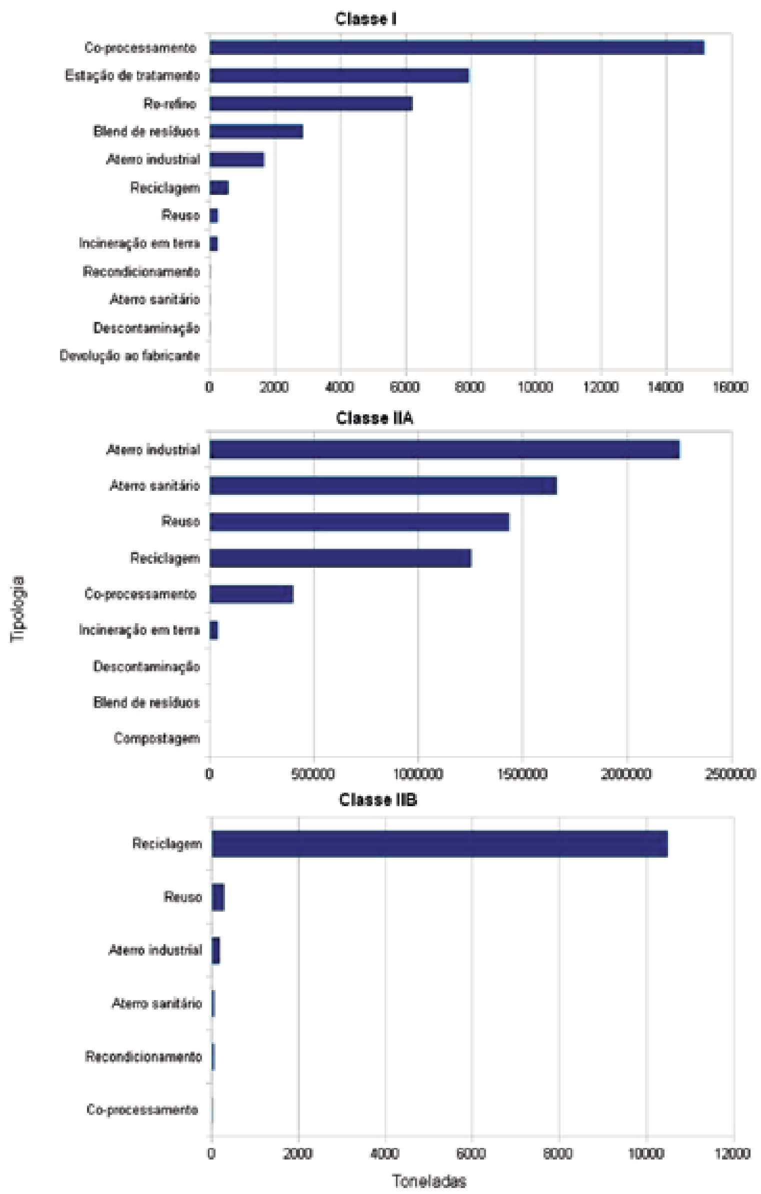
The national oil production grew approximately 26% from 2005 to 2010. With regard to water, it appears that, after a slight increase, the relative water abstraction to oil production has been reducing over the last two years of the period. The same can be said with regard to effluent generation, highlighting the strong decrease in 2010. The generation of residues, in turn, presented a considerable drop in the period, both in absolute or relative terms.

A technical note (NT) written by IBAMA[2] has presented the consolidated results regarding the generation and final disposal of solid wastes from off-shore oil exploration

2 NOTA TÉCNICA (Technical Note) CGPEG/DILIC/IBAMA N° 07/11, PROJETO DE CONTROLE DA POLUIÇÃO (Polution Control Project), Solid waste from oil and gas exploration and production in Brazilian off-shore sedimentary basins in 2009 – Consolidated results of Technical Note (Nota Técnica CGPEG/DILIC/IBAMA n° 08/ 08).

and production ventures for 2009. The NT informs Class I and Class IIA residues[3] are forwarded to a broader range of destinations in absolute terms, when compared with the Class IIB residues, which are earmarked for waste recycling, thus reflecting the residues types included in each class (Figure 16).

FIGURE 16. QUANTITATIVE TOTALS FOR RESIDUES BY DESTINATION, BY WASTE CLASSIFICATION

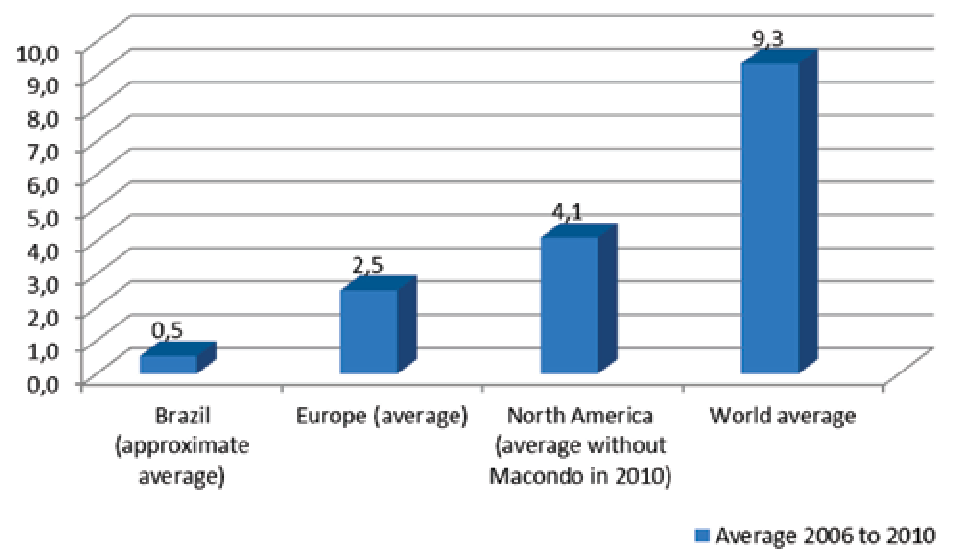


Source: IBAMA, 2011.

3 Residue classifications in accordance with the technical standard (Norma Técnica NBR-ABNT 10004/2004, that defines the following groups: Class I-hazardous residues; Class IIA – non-hazardous and non-inert residues; Class IIB – inert and non-hazardous residues.

With respect to crude oil and derivative spills and the environment, it is evident the Brazilian oil and gas E&P industry performance is significantly better than the world average, as indicated in Figure 17. This presents the average spill volumes from 2006 – 2010 related to the average hydrocarbon production in that period. The recent crude oil spill (November 2011), from the Frade field in the Campos Basin, Rio de Janeiro, was an infrequent event and, fortunately, involved small mounts, but that certainly will lead to procedural improvements to be adopted by all operators in the country.

FIGURE 17. SPILL VOLUMES IN RELATION TO E&P PRODUCTION (T SPILLED /10^6 T OF HYDROCARBON PRODUCTION)



Source: OGP, 2010.

3 ECONOMIC AND SOCIAL-ENVIRONMENTAL REGULATIONS THAT IMPACT THE OIL AND NATURAL GAS INDUSTRY

3.1 Key regulatory aspects (legislation) and norms (compulsory or voluntary) that impact the Brazilian oil and gas industry

3.1.1 The National Policy on climate change quotas and economic instruments

Brazil confirmed in the Copenhagen Agreement and at the Conference of the Parties (COP 16) in Cancun, their voluntary national targets to reduce greenhouse gas emissions (GHG), with reductions between 36.1% and 38.9% of projected emissions up to 2020. These quotas were defined in the Política Nacional sobre Mudança do Clima (PNMC), (National Climate Change Policy), established by law 12.187/2009.

The (PNMC) determines principles, guidelines and instruments to achieve the national targets regardless of developments in global climate agreements. To this end, it uses industry mitigation and adaptation plans to meet climate change seeking to consolidate a low-carbon economy.

From the proposed contributions for each segment in the national emission scenario, it is clear that national efforts will be concentrated on controlling deforestation. In addition, it is noted that the energy quotas are those included in the Plano Decenal de Expansão da Energia – (PDE) (2011-2020) (Ten Year Energy Expansion Plan), meaning that the effort in this sector is already embedded in the foreseen supply expansion.

There isn't, however, a prediction of specific mitigation for the oil and gas industry, which does not mean that the industry is not seeking economically viable ways to reduce its emissions intensity. This could be to meet strict environmental issues, or in an international business context, which, as indicated below, approaches to somehow penalize GHG emissions.

3.1.2 The predominant Brazilian environmental regulations that impact the oil and gas industry

Practically all the oil and gas production chain is affected by the Brazilian environmental legislation applicable to industrial operations. Most of it is of a general character, i.e. applicable to any industrial typology, there are, however, some legal instruments specific to this industry, as is the case, for example, some specific resolutions and decrees about licensing, the actual petroleum laws and regulations on contingency.

ANP, through its decrees and resolutions, also establishes some environmental and operational safety requirements relating in particular to concession contracts, in accordance with the provisions of Law 9.47897, which created it. Another regulation that affects the industry's relationship with the environment is Decree 2.70598, which sets the criteria for the calculation and collection of government contributions applicable to exploration, development and production of oil and natural gas activities. According to this Decree, it is from 10 to 40% of the income for the special contribution to the MME – Ministry of Mines and Energy, to the MMA – Ministry of environment, the States and municipalities, depending on the location/production volume.

The following international conventions and protocols merit being highlighted concerning, in particular, maritime pollution and the liability and compensation for damage caused by oil pollution. Brazil ratified the MARPOL – "*International Convention for the Prevention of Pollution from Ships, 1973*", with the modifications introduced in the 1978 Protocol and the OPRC – "*International Convention on Oil Pollution Preparedness, Response and Co-operation, 1990*", In addition to the CLC – "*International Convention on Civil Liability for Oil Pollution Damage, 1969*" - amended in 1992, and the "*International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004*", by Legislative Decree Nº 148/2010.

To manage the effects of pollutants associated with the growth of the motor vehicles fleet, the Brazilian Government conceived a little over 25 years ago, the air pollution control program for motor vehicles (PROCONVE). It is a successful program, which has resulted in a 98% reduction in carbon monoxide emission by light vehicles. For heavy vehicles, the reduction was around 80%, which brought great benefits to air quality in metropolitan regions, which possessed large fleets of buses and trucks. The technological highlights from the program are associated with the introduction of catalytic converters in vehicles, electronic fuel injection systems and improvements in the quality of automotive fuels themselves.

It is in this context the industry's ongoing effort is to improve the quality of diesel, which should also be in line with the evolution of vehicle engines. Recently, this was consolidated when diesel S-500 (500 parts per million – ppm sulphur –) was replaced by S-50 (50 ppm). The next step, scheduled for early 2013, will be a 10 ppm sulphur diesel, for vehicles with appropriate technology engines, to ensure the reduction of atmospheric pollutant emissions enabled by the new fuel. It should be noted that this is a complex issue, because diesel quality improvements involve modifications in industrial processes that lead to increased greenhouse gas emissions

3.1.3 Government endeavors involving the environment and the oil and gas industry

The entire oil and gas industry production chain is subject to control by the environmental agencies. The CONAMA Resolution 237/97 establishes that IBAMA emits environmental licenses for ventures and activities that are potentially capable of generating significant environmental impact located or developed within Brazilian territorial water and its continental shelf.

Thus, for off-shore exploration and production seismic surveys, it is IBAMA's responsibility, while such activities when undertaken on the continent, are under the respective State environmental agencies control. The State environmental agencies are also responsible for the licensing and control of other oil and gas supply chain activities, with the exception of pipelines. As these usually cross more than one state, they are also under the authority of IBAMA, or gas stations that, under the Covenant, can be passed on to the responsibility of the municipalities.

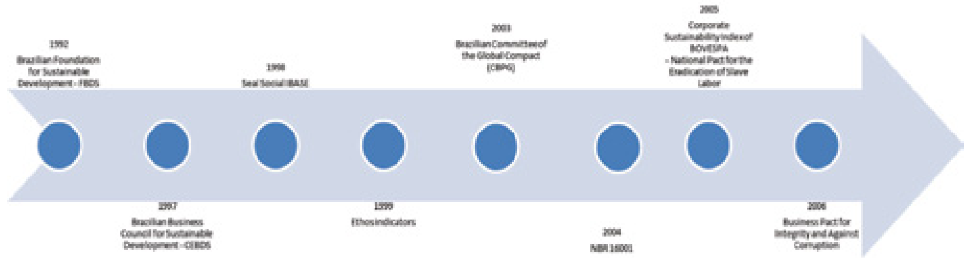
With respect to contingency measures for water under federal jurisdiction, other government entities, in addition to the environmental bodies, have a prominent role in accordance with law 9.966/00, notably ANP, as the regulatory body, and the Brazilian Navy, as the maritime authority.

4 BUSINESS PRACTICES FOR SUSTAINABLE DEVELOPMENT (1992-2011)

4.1 The national scenario

The chronology of corporate sustainability-related instruments in Brazil mirrors international developments, sometimes anticipating demands and serving as a model for global strategies. The main national events are highlighted in Figure 18.

FIGURE 18. CHRONOLOGY OF MAJOR NATIONAL INITIATIVES RELATED TO CORPORATE SUSTAINABILITY



Source: MAGRINI, 2011

Two years after the World Business Council for Sustainable Development (WBCSD) was founded and five after the installation of FBDS – Fundação Brasileira para o Desenvolvimento Sustentável (Brazilian Sustainable Development Foundation), the Conselho Empresarial Brasileiro para o Desenvolvimento Sustentável – (CEBDS) (Brazilian Business Council for Sustainable Development) was created entity linked to WBCSD.

Currently the CEBDS has 69 member companies, including several from the oil and gas sector, and is a platform to disseminate and recommend sustainable practices to Brazilian business.

The model of the Instituto Brasileiro de Análises Sociais e Econômicas (Ibase), (Brazilian Institute of Social and Economic Analyses), launched in 1997, before the GRI standard, proposed a model report for companies to communicate to stakeholders the various aspects of its performance, including those associated with social and environmental responsibility. The Ethos Institute sustainable evaluation model, launched in 1998, is based on the Ibase and GRI proposals, adding details of the organization's principles and activities.

In 2003, the Comitê Brasileiro do Pacto Global (CBPG), (Brazilian Global Compact Committee), was created through a partnership between the Ethos Institute and the United Nations Development Programme (UNDP), with seeking to encourage Brazilian companies (or those operating in Brazil) to adopt the principles of the Global Compact. Currently, 30 organizations participate in the CBPG. Recently, other business pacts aimed at corporate social responsibility have been established by the Ethos Institute. Notable among these are: the Pacto Nacional para Erradicação do Trabalho Escravo (National Pact to Eradicate Slave Labor), created in 2005 in conjunction with the International Labor Organization (ILO) and the NGO Reporter Brazil; and the Pacto Empresarial pela Integridade e Contra a Corrupção (Corporate Pact for Integrity and Anticorruption), working since 2006 in conjunction with other institutions, such as UNDP, CBPG and the Ford Foundation, which already has 280 signatory companies.

Another forerunner of an international instrument was the ABNT NBR 16001 standard, created in 2004, which served as one of the references for the ISO 26000 standard on social responsibility. The NBR 16001 standard deals with issues such as child protection and the semi-slavery worker, health, safety and combating discrimination, in a systematic and planned way, helping companies to establish effective systems to manage social responsibility.

The Bolsa de Valores de São Paulo (Bovespa) (São Paulo Stock Market) also developed an instrument to evaluate the sustainability of companies with shares traded in that institution. The Índice de Sustentabilidade Empresarial (ISE), (Corporate Sustainability Index), released in 2005 based on a partnership between Fundação Getúlio Vargas (FGV) (Getúlio Vargas Institute) and Bovespa, sought to select the most sustainable forty companies. In the ISE, companies are selected in an integrated manner, from the concept of a triple bottom line (TBL), which includes financial, social and environmental elements.

4.2 Corporate sustainability in the oil and gas industry

4.2.1 The international scenario

Most of the organizations that deal with specific environmental issues for the industry were created before Rio 92. The oil and gas industry has been alert to sustainability issues since the start of the environmental movement, formed soon after the Stockholm Conference, the International Petroleum Industry Environmental Conservation Association (Ipieca). Launched in conjunction with the United Nations Environment Program (UNEP), in 1974, Ipieca is the only global association that deals with environmental and social issues for the entire oil and gas production chain, still being the main industry communication channel with the United Nations.

Ipieca affiliates represent more than half the global oil production. The organization helps the industry to improve its environmental and social performance through development, sharing and promoting good practices and by working in partnership with stakeholders. Among the Ipieca guidelines are included the Global Water Tool, developed with the WBCSD, guidelines for GHG Emissions Reporting and the Biodiversity and Ecosystem Services Guide and Checklist. Ipieca works with other industrial associations such as the International Association of Oil and Gas Producers (OGP), which jointly produced, in 2011, the Guidelines for Voluntary Sustainability Reporting for the industry.

OGP operates exclusively in oil exploration and production and establishes guidance on numerous operational issues, including the environment and operational safety. OGP prepared, together with intergovernmental organizations such as UNEP and NGOs such as IUCN (International Union for Conservation of Nature), various guidelines on oil operations, including guidelines for tropical forest operations, exploration and production in mangrove areas, etc. It also publishes reports on the environmental performance of exploration and production industry-focused companies.

The Global Initiative (GI) is an “umbrella” program, launched in Cape Town in 1996, through which governments, represented by the International Maritime Organization (IMO), and the oil industry represented by Ipieca, work together to assist countries to develop structures and capacity-building to respond to oil spills, through workshops, simulated exercises and training.

Another important actor in the area is the International Finance Corporation (IFC), the private arm of the World Bank, which draws up technical reference documents on the basis of best practices in environment, health and safety (EHS Guidelines) specific to various industries, including the oil industry.

The Latin America and Caribbean Regional Association of Companies in the Oil, Gas and Biofuels Industry (ARPEL), founded in 1965, aims to promote the integration of the region’s industry and its growth, as well as to encourage and support companies to maximize their contribution to the region’s sustainable development. Its members represent more than 90% of the region's production chain activities and include national and international oil companies, technology and goods and services. Since 1976 ARPEL has been the special advisory member to the United Nations Economic and Social Council (ECOSOC). In 2006, the Association declared its adherence to the 10 Global Compact principles.

All these organizations draw up guidelines, directives or standards, always with the Industry's direct participation and often in partnership with NGOs and intra-governmental institutions. They discuss subjects as varied as biodiversity, transparency, human rights, residues, effluents, emissions, relationships with communities, among others.

4.2.2 The national scenario

The Country's recent significant increase in oil production has increased corporate responsibility and is leveraging more resources and new technologies in the environmental area.

From 1999, with the deployment of CTPetro, a research promotion fund provided by law 9.478/97, the relationship between the oil and natural gas industry and the scientific community gained new momentum. It also benefits with a significant financial support from oil and natural gas royalties. Almost all research projects related to the industry were made with these resources.

Two national organizations of the sector have represented an important articulation channel and elaborate social responsibility and sustainability policies for the Brazilian oil and gas industry: the Instituto Brasileiro de Petróleo, Gás e Biocombustíveis (IBP) (Brazilian Institute of Petroleum, Gas and Biofuels) and the Sindicato Nacional das Empresas Distribuidoras de Combustíveis e de Lubrificantes (Sindicom) (National Union of Fuel and Lubricant Distributors). IBP has a greater focus on exploration, production and refining activities and has more than 200 member companies. Its mission is to contribute to the national oil, gas and biofuels industry development, to produce a competitive sustainable, ethical and socially responsible industry.

Sindicom was founded in 1941, and is focused exclusively on fuel distribution and represents 11 main distributors, with the mission to promote operational efficiency, quality products and services, the adoption of safety, health and environmental standards, as well as represent the members in government dealings.

Among IBP's main achievements are: the environmental projects monitoring the effects of drilling gravel in shallow and deep marine environments (MAPEM), developed in partnership with the Federal University of Rio Grande do Sul; participation in making the Ibama Environmental Licensing Guide, which aimed to advise oil companies regarding the degree of environmental sensitivity of areas to be auctioned; and involvement in the construction of the Sistema de Gerenciamento de Segurança Operacional – (SGSO) (Operational Security Management System, regulated by the ANP). IBP has also supported the elaboration of studies on which was based the Technical Regulation N°. 2/2011 - Dutos Terrestres para Movimentação de Petróleo, Derivados e Gás

Natural (RTDT) aimed at Land Pipelines for Oil , Derivatives and Natural Gas Transportation –, published by ANP on 03/02/2011. Those studies were prepared by the Centro de Tecnologia em Dutos[4] – (CTDUT) (Pipeline Technology Center). The regulation laid the essential requirements and minimum operating security standards for on-shore oil and gas pipelines and represented an important step towards to ensure the integrity of national pipeline network.

In partnership with the Ethos Institute, IBP launched in 2004 the Social Responsibility Indicators specifically for the oil and gas industry. It also signed in 2005, the National Pact for the Eradication of Slave Labor.

IBP coordinates, together with the Ministries of Mines and Energy and the Environment, in addition to Petrobras, the Environmental Thematic Committee of PROMINP - CTMA, created in 2008. Through the CTMA, which brings together the oil and gas industry and the government and aims to foster an ongoing dialogue to improve the industry's environmental management activities, environmental regulatory proposals were created specifically for the area. One of the main products of this process was the recent decree by the Ministry of the Environment which disciplines off-shore environmental licensing by introducing important innovations in these procedures, such as the licensing by geographical area and the possibility to validate and use the technical information contained in environmental studies. Other initiatives, such as the discipline of relationship between block concessions and environmental viability and the mounting of an environmental database in the industry, are under way in the CTMA context. The Committee is an extremely innovative experiment in terms of creating a permanent dialogue channel between the business sector and the government seeking to improve licensing and the oil and gas industry environmental management.

Another relevant IBP service is the offer, since 1999, of industry training courses. In 2009 the Postgraduate Institute of Petroleum was created, enabled by MEC. IBP currently offers about 100 courses annually, serving more than 2,000 students per year. Part of these courses is directed specifically to the environmental area, and is even for government officials.

Sindicom also merits attention with several environmental initiatives, among which is the Programa Jogue Limpo (Clean Play Program). The program is a system of reverse logistics of post-consumer plastic lubricant containers, structured and provided by the manufacturers, importers and distributors of lubricants. The program has already collected more than 100 million packages.

The SEH Manual – safety, environment and health – for Gasoline Service Stations also represents an important initiative, which was the result of a partnership between Fecombustíveis, Sindicom and IBP. Sindicom also develops activities designed to support the fuel distribution sector in service station environmental licensing, through skill building strategies and dialogues with the licensing agencies, seeking to improve standards and the effective legalization of the industry.

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4 Technological Center for the technical development of pipeline, CTDUT was inaugurated in 2006, the fruit of a partnership between Petrobras, Transpetro and the Pontifícia Universidade Católica do Rio de Janeiro (PUC-RJ), acting as a shared laboratory for the pipeline community use.

In terms of emergency response, Petrobras Environmental Protection Centers (CDAs) and its advanced bases form the largest network of environment protection in Latin America. Located in strategic operation points, the centers complement existing local contingency plans at terminals, refineries and other company units, ensuring maximum protection to operational units in case of an emergency.

Today, they are ten CDAs in operation across the country, with 13 advanced bases, and two vessels manned 24 hours per day. Today the concepts are being discussed of Area Plans and Mutual Aid Plans, set out in the Decree 4871/2003[5], on the understanding of the possibility other companies will use the CDAs, if necessary.

Several oil and gas operators working in the country are certified in accordance with the principles defined by the ISO 14001 and OHSAS 18001 standards. Similarly, many are adopting the GRI proposed sustainability report model, which has improved the quality of social-environmental information periodically disclosed by the companies. The adhesion of the oil and gas companies to the various Brazilian initiatives in the sustainability area has been continuous and growing.

Petrobras and most international oil and gas companies operating in Brazil have drawn up their sustainability reports in accordance with the grade A+ (highest adherence) of the GRI format.

The Carbon Disclosure Project (CDP) assigns points to the transparency with which companies manage the risks and opportunities for the business represented by issues related to global climate change. Most Brazilian oil and gas industry companies, which have replied to the CDP proposed questionnaire scored in the range of high transparency.

It is important to note that in recent years in face of the growing global climate change agenda, virtually all Brazilian companies in the oil and gas industry have created internal structures to deal with the issue and developed corporate policies and strategies related to it.

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5 Decree No. 4,871, November 6, 2003 – "Adopts provisions concerning the imposition of Area Plans to combat oil pollution in water under national jurisdiction and gives other action"..

5 CHALLENGES AND OPPORTUNITIES FOR THE INDUSTRY ON THE ROAD TO SUSTAINABILITY

5.1 Key industry trends within the sustainability framework

5.1.1 Regulatory perspectives that impact the industry

Brazil already has market mechanisms to promote projects of carbon emission reductions of greenhouse gases under the clean development mechanism (CDM), with the establishment of a system for carbon credits trading in the BM&F, called Mercado Brasileiro de Redução de Emissões – (MBRE) (Brazilian Emission Reduction Market).

Although the MBRE has been so far restricted to credits from CDM projects, Art. 11 of PNMC allows the MBRE to acquire a broader scope and also recognizes that the transacted volumes are liquid securities. This accounting recognition is an important factor to establish the market transaction value, which until the PNMC, had not yet legal support. With this, the carbon market in Brazil may evolve to house the efforts to meet the national goals, as provided for in § 3º of Art. 4 of Decree Nº. 7.930/2010.

The §4º of Art. 6º of the same Decree provides that the proposed mitigation actions in the sectoral plans are also deployed through the Clean Development Mechanism or other mechanisms within the United Nations Framework Convention on Climate Change, which would allow the interconnection of the Brazilian market with the markets of other countries or regions which are governed by the Convention.

Outside the PNMC scope, but in line with its goals, the Associação Brasileira de Normas Técnicas -(ABNT) (Brazilian Association of Technical Norms) by means of the standard ABNT NBR 15948: 2011, June 2011, developed the principles, requirements and guidelines for the creation of a voluntary carbon market in Brazil.

5.1.2 Scenarios in Brazil

The projections of Empresa de Pesquisa Energética – (EPE) (Energy Research Company) responsible for planning and studies that form the basis for the actions of the Ministry of Mines and Energy – (MME) for oil production in Brazil can be found in the following table.

TABLE 1. DAILY OIL PRODUCTION PROJECTION (MILLION BPD)

Resource	Year									
OIL	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
RND-E	0,000	0,003	0,038	0,101	0,158	0,224	0,264	0,280	0,288	0,289
RND-U	0,000	0,000	0,000	0,000	0,010	0,080	0,157	0,217	0,282	0,336
RC	0,155	0,320	0,465	0,725	0,966	1,293	1,815	2,552	2,969	3,280
RT	2,170	2,137	2,297	2,709	2,690	2,764	2,648	2,494	2,332	2,188
Total	**2,325**	**2,460**	**2,800**	**3,536**	**3,824**	**4,360**	**4,885**	**5,544**	**5,870**	**6,092**

RND-E – Forecast contribution of undetected resources contracted in exploration blocks under concession until Round 10; RND-U – Forecast contribution of undetected resources in part of the area of the Union; RC – Forecast contribution of the contingent resources, in exploratory evaluation stage discoveries in blocks under concession until Round 10; RT – Forecast production of total reserves in fields already in development or production. Source: EPE, 2011c.

The above projections are in the Ten Year Energy Plan (PDE) 2011-2020, which is published annually by EPE. The EPE studies are the primary reference for all energy-related sectors. Among these studies, the national energy plan (PNE) can also be highlighted, which brings long-term analyses also for the oil industry. The latest version of PNE is for 2007 and brings much more modest projections for oil production, as at that time the discovery of the pre-salt reserves had not yet been announced.

With regard to natural gas, the Brazilian reserves were 423 billion m^3 in 2010, with the country in 34th place in the ranking of proved reserves of natural gas. With a production of 14.4 billion m^3, Brazil held the 35th position among the world's largest producers. The estimated values to produce NG by EPE are presented in Table 2, where a projected increase of 108% from 2011-2020 can be seen.

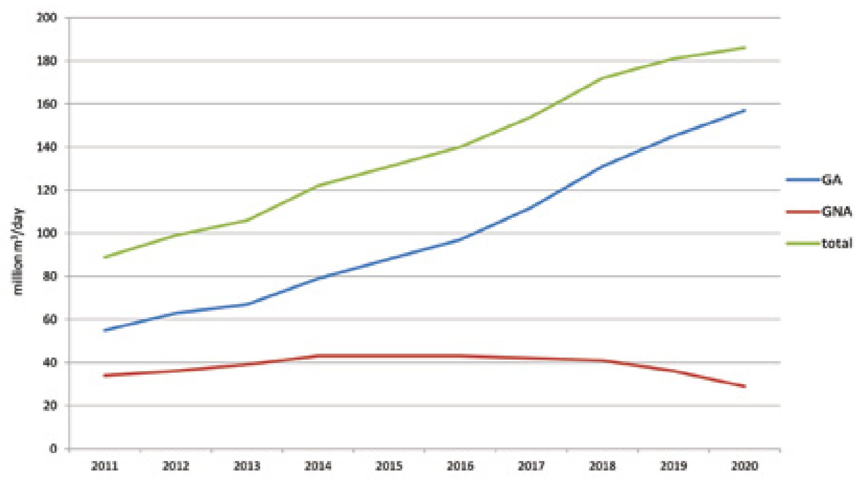
TABLE 2. DAILY NATURAL GAS PRODUCTION PROJECTION (MILLION M^3/DIA)

Resource	Year									
Gas	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
RND-E	0,000	0,117	1,635	3,910	5,279	11,513	17,663	28,016	33,288	35,113
RND-U	0,000	0,000	0,000	0,000	0,538	3,205	6,362	9,225	13,212	18,719
RC	4,170	8,632	11,918	20,313	29,892	40,444	57,825	81,408	98,971	116,045
RT	84,958	90,526	94,899	101,591	101,344	100,004	96,366	90,651	81,108	70,615
Total	**89,128**	**99,275**	**108,451**	**125,814**	**137,053**	**155,166**	**178,217**	**209,300**	**226,580**	**240,491**

Source: EPE, 2011c.

The total production forecast of natural gas from contingent resources (RC) and total reserves (RT) reveals a predominance of associated gas, as shown in the graph in Figure 19 below.

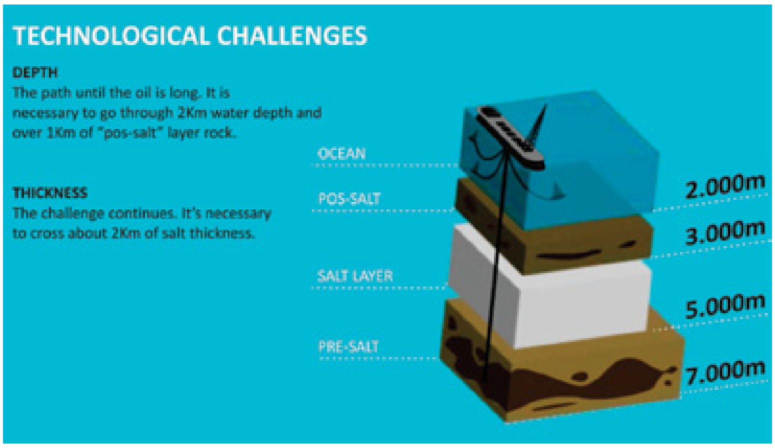
FIGURE 19. NATIONAL PRODUCTION FORECAST OF NATURAL GAS, FROM DISCOVERED RESOURCES (RESERVES AND CONTINGENCY)



Source: EPE, 2011c

The discovery of new oil deposits in ultra-deep water (1,500 to 3,000 meters) opened a new frontier for the Brazilian oil and natural gas industry. The pre-salt layer discovery (Figure 20) established a new position for the country in the international oil and natural gas market, increasing substantially the Brazilian proven reserves and viably almost tripling production by 2020. The estimated reserves of 50 billion barrels of oil in the Pre-Salt layers are sufficient to insert Brazilian reserves among the 10 largest in the world. It is estimated that the participation in national production from pre-salt oil will rise from 2% in 2011 to 40.5% in 2020.

FIGURE 20. SCHEMATIC GEOLOGICAL PROFILE OF THE PRE-SALT PROVINCE

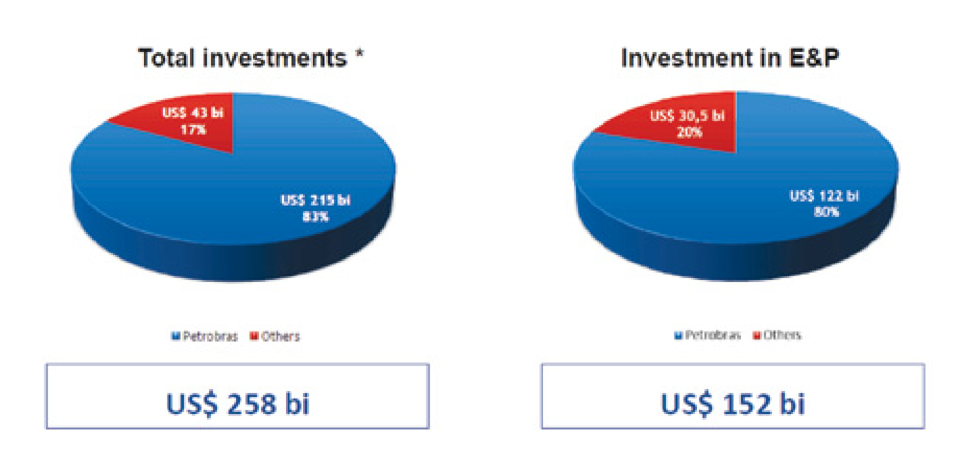


Source: Petrobras

Operating under such geological conditions and the large volume of oil accumulations already found, will require a large number of production units in each field. The transport infrastructure development for oil and natural gas, produced at distances of about 300 miles from the coast, is among the major challenges to be overcome throughout this decade. Petrobras and its affiliates that operate in the country study options (such as support bases, ocean terminals and remote operation centers) to guarantee logistical support, operational and production safety. It will require new production platforms, over a hundred support craft, plus the largest fleet of drilling rigs to come into operation in the next few years. There are forecast of 146 of new vessel constructions, with the 70% to 80% national content requirement, at a total cost estimated at $ 5 billion. The construction of each vessel will generate about 500 new direct jobs; 3,800 new places for crew members will be opened.

Major investments are planned for the Pre-Salt and post-salt fields, until 2015. It is estimated a total exceeding $ 250 bi, along the oil and natural gas value chain, including the entire transportation infrastructure, as shown in Figure 21 below:

FIGURE 21. INVESTMENT FORECAST 2011-2015



(*) Investiments in biofuels not ncluded.

Source: Petrobras/IBP

5.2 Challenges and opportunities for the industry within the sustainable development framework

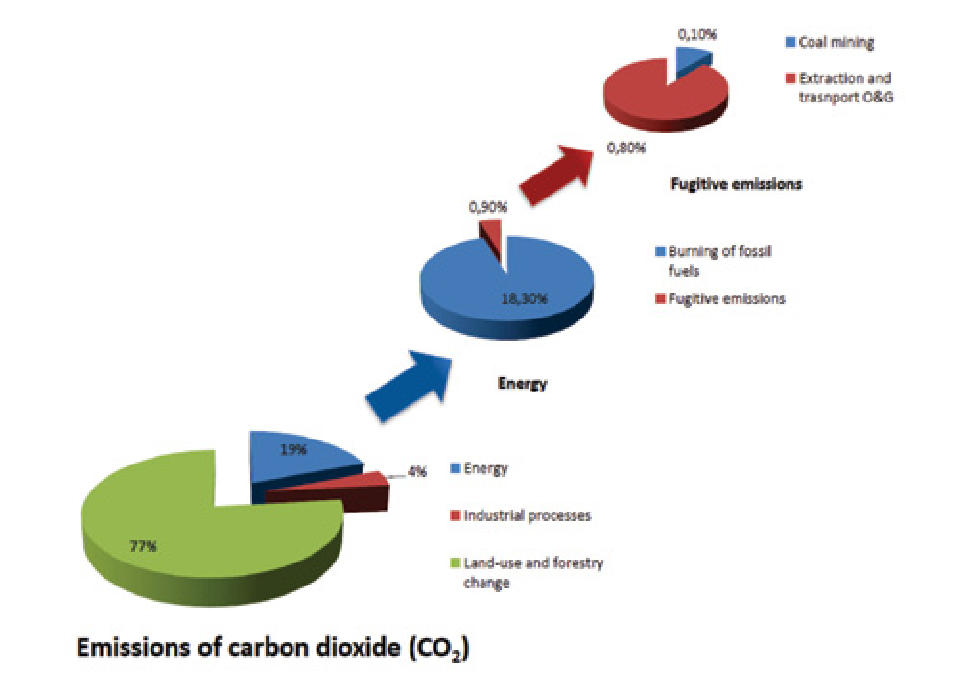
5.2.1 GHG emissions and mitigation options

The contribution of the processes of extraction, transport and processing of oil and gas with regard to emission of GHGs is accounted for in the chapter of Fugitive Emissions of the Brazilian Inventory of Anthropogenic Emissions and Removals of Greenhouse Gases, of the Ministério da Ciência, Tecnologia e Inovação-(MCTI) (Ministry of Science, Technology and Innovation).

Emissions associated with oil and natural gas includes leakages of methane (CH_4) during the extraction process (venting), transport and distribution by pipelines and vessels and during refinery processing. Also considered are CO_2 emissions by nonworking burning (flaring) in the platforms extracting oil and natural gas, and in the refineries.

With regard to CO_2 emissions, the energy sector was responsible in 2005 for 19.2% of the total emissions in Brazil; the burning of fossil fuels accounted for 18.3% and extraction, transport and processing of oil and natural gas for 0.8%, as can be seen in Figure 22.

FIGURE 22. CARBON DIOXIDE EMISSIONS IN 2005, IN BRAZIL



Source: MCT, 2010.

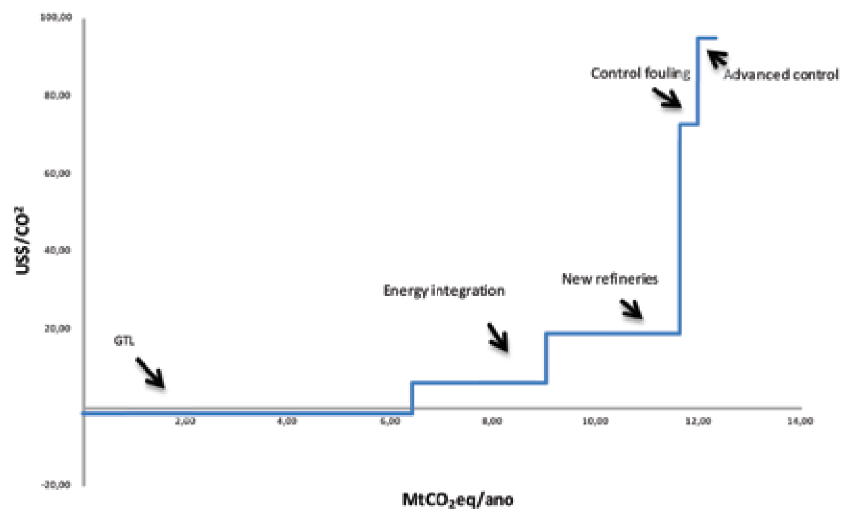
The energy sector was also responsible for 3.0% of total CH_4 emissions, 1.9% being associated with the burning of fossil fuels and 0.8% for the extraction, transport and processing of oil and natural gas[24].

The Low-Carbon Scenarios Study published recently by the World Bank (De Gouvello, 2010) show some steps to reduce GHG emissions in oil and natural gas production and refining activities. The measures include new and existing refineries and the introduction of gas-to-liquid (GTL) plants. The measures discussed below are a few examples of what can be applied to reduce GHG emissions by the industry. It should be noted the evaluation of any such measure should consider its cost-effectiveness, its economic attractiveness and technical feasibility, among others, in addition to the potential GHG emission reductions.

The alternatives considered for existing plants are: energy integration reduced formation of encrustations and advanced process controls. In respect of new refineries, an optimized model was deemed necessary that focused on diesel production integrated with petrochemical production. GTL plants are capable of producing liquid fuels (with emphasis on high-quality diesel) from natural gas, taking benefit of the very same gas that would have been burned in flares on offshore oil platforms.

The combination of these various measures would avoid an average volume of GHG emissions of 12.3 $MtCO_2e$ per year. According to this World Bank study, the most cost-effective measure is to introduce GTL technology, which also avoids the largest emission volumes. The most expensive is the advanced emission controls in existing refineries, as shown in Figure 23 below.

FIGURE 23. MARGINAL COST CURVE OF REDUCTION



Source: DE GOUVELLO, 2010[6].

6 Adapted by Amaro Pereira Jr.

The introduction of CCS (Carbon Capture and Storage) is also a possible oil sector emissions mitigation measure. However, the World Bank study shows the cost of mitigation associated with this alternative can be more than 100 US$/t$CO_2$e. In addition, some technology issues still need to be addressed to make full use of CCS technology.

5.2.2 Opportunities for the industry within the sustainable development framework

If in 2008/2009 the economic crisis pointed to a dramatic, world-wide reduction of investment by oil companies, the current trend seems to be distinct. Now the oil companies know that this crisis should be more lenient and that any price reductions would not mean much in the medium/long term. There is almost a consensus that the farthest horizon will reveal rising prices. Recently the IEA (International Energy Agency) revised downwards its forecast for global oil demand growth. According to the previous 2011 forecast, about 89.25 million barrels of oil per day would be consumed, while in 2012 the demand would grow to 90.71. According to the new forecast, projected consumptions are respectively 89.2 and 90.5 million bpd, which expresses a slight reduction. By way of comparison, world oil consumption fell to about 1.2 million bpd from 2008 to 2009, when the crisis broke.

The prudence with respect to investments observed in the earlier event, has been replaced by a belief that, in the long term, a medium oil and gas demand profile will remain. This mindset shift is justified when considering how much the growth of emerging markets will represent.

The Brazilian oil and gas industry vertiginous development has an important role in this new global market. There is strong evidence in the country that investment trajectories will be amended in the light of what happens in the rest of the global economy. In EP alone, investments have grown substantially in the last 10 years, making Brazil one of the largest worldwide resources customers. This industry is an important pillar for the country's economic growth, consequently boosting the dynamism of its local supply chain. The projections for the coming years point to a great opportunity to develop a competitive, goods and services supply chain.

Oil has a high multiplier of value added factor, which could result in significant socio-economic benefits for the country in terms of income, employment, qualification of labor, technological development and sustainable economic growth. There are serious challenges and bottlenecks for these benefits to be captured, especially related to raw material supply, skilled labor and technology. It is hoped that through specific public policies, encouraging the development of local suppliers, these challenges and bottlenecks can be largely overcome.

It should be highlighted that, in the wake of the pre-salt discoveries, many major suppliers to the oil and gas supply chain, invested heavily in research and development projects (R&D). This was to ensure greater competitiveness in the face of more stringent Local Content requirements and a leading-edge position for Brazilian industries.

Among these companies, some are taking up space in the Federal University of Rio de Janeiro "Campus"– UFRJ, linked to a Technological Centre around the Petrobras Research Center, such as Schlumberger, Baker Hughes, Halliburton, FMC and others.

Major oil industry equipment producers have consolidated R&D structures. Thus, the essential insertion of micro and small enterprises (MSE) in this supply chain will only represent an important contribution to the industry if the major producers develop co-operative projects with the MSEs, and funding agencies offer them financial support to participate in the process.

The Financiadora de Estudos e Projetos (Finep/MCTI) (Studies and Projects Fund) has been developing projects in a cooperation between companies and science and technology institutions (STIs) which offer solutions to the oil industry technological challenges, including environmental issues, both for prevention and the recovery of degraded areas. Since the allocation of resources for the Fundo Setorial do Petróleo – (CTPETRO) (Oil Sector Fund), based on the Petroleum Act around one billion Reals (from 1998 to 2010) has already been invested in R&D. Additionally, ANP included in their concession contracts obligatory investments (Special Participation Payment) in R&D by the concessionary companies, of 1% of the production. This has already reached around five billion Reals (From 1998 to 2010), of which part has been systematically invested to develop operational safety, integrity of facilities and accident prevention.

It is important to highlight that the oil production increase with the pre-salt reserves does not necessarily imply an opinion change or Brazil's efforts in the fight against global warming. First, because the country already has a diversified economy in which oil revenues will not be dominant. And the other countries experiences such as Norway and the United Kingdom show that the oil reserves do not affect an active position and leadership in the fight against global warming. Second, because the greatest effect of those reserves shall be to generate an income that can be channeled into development funds, as occurred in the above-mentioned countries. These funds can support greater investments in education and technological development and other sustainable development constraints, such as health, urbanization and housing projects, as provided for in the pre-salt regulating law. Additionally, these resources can feed the sovereign wealth funds that will help the country in economic stabilization with ante cyclic policies.

Both the country's global leadership in the environmental area and by the technological excellence degree already reached enables operational development with adequate environmental security and protection. Furthermore, the Brazilian oil and gas industry understands its growth will open promising windows to leverage investments in green business and jobs, as well as sustainable development projects, representing an effective contribution to the greener economy transition process, as highlighted in the next chapter.

5.2.3 The industry's contributions to the transition to a green economy

The industry's reference in the definition and principles that guide the green economy transition, are expressed in UNEP's report, released in 2010, quoted below:

> "Promote human well-being and social equality, significantly reduce environmental risks and ecological scarcity; in a green economy, income growth and employment must be driven by public and private investments geared to pollution and carbon emission reduction, improving energy efficiency and resources and the prevention of loss of biodiversity and ecosystem services." (UNEP, 2010).

Following a large investment in deepwater exploration technology development, Brazil went on to hold leading edge technology that enabled the national oil supply self-sufficiency. This scenario promotes a significant increase in demand for the provision of environmental services, generating new businesses and jobs. On the other hand, it also enables the industry to promote investments in renewable energy source development, as well as develop business strategies to take benefit of such alternatives, as was the successful case of adding alcohol to gasoline, and, more recently, the strategy of incorporating a percentage of biodiesel to diesel.

Many businesses are directing much of its efforts to research and technological development that will ensure that over the coming years the production of oil and gas in this new exploratory frontier. An example is the technological program to develop the Petrobras Pre-Salt reservoirs (Prosal), which is being deployed in the light of other successful initiatives developed by its Research Center (Cenpes). This was inspired by Procap[7], instrumental in developing the company's excellence in deepwater production. In addition to developing proprietary technology, Petrobras works with a network of universities that contribute to the formation of a solid national technological portfolio.

Several sustainability advances have been gained by the industry. Highlighted is the increasing adoption of voluntary market mechanisms geared to social and environmental responsibility and corporate sustainability and increasingly incorporating these issues into company strategic planning.

In addition to these, there are other vital initiatives such as adopting measures to incrementally increase the sustainability of the oil and gas industry through:

7 Programa Tecnológico de Águas Profundas – (Procap) (Deepwater Technology Program). In the new Procap Future Vision Program, solutions searches are emphasized to significantly change the current pattern of deepwater field development. Among the innovations being developed is the intensive use of nano-technology and submarine production processing systems.

- encourage the use of energy generated by renewable resources, such as the production and marketing of biofuels;
- risks and opportunities analyses related to the reduction and management of greenhouse gas emissions and climate change;
- generate livelihood opportunities based on the increased level of employment in the industry, and labor force training demand. More than 200 thousand people need to be trained by 2014;
- establish more rigorous criteria to assess the socioeconomic and environmental impacts caused by the industry activities in the communities where it operates, adopting, when appropriate, mitigation and compensatory actions throughout the project;
- prioritize transparency as an ethical principle that prevails in all the industry's operations and relationships with stakeholders;
- engagement and dialogue with stakeholders.

Brazilian oil exploration and production contracts have clauses to ensure national products and services suppliers the right of first refusal on an equal terms basis regarding price, deadline, and technology against the international market. There is also a minimum percentage requirement of Local Content to be observed in goods and services acquisition, as well as exploration activities in production field development. The measure seeks to ensure internal market use to encourage Brazilian industry development.

The present capacity of the national goods and services sector is still, however, insufficient to meet the demand foreseen in the oil and gas industry. Faced with this situation, strategies to promote the supply chain development will be essential, with initiatives such as anticipation of strategic vendor support contracts, fundraising and attracting new partners.

Some studies are being conducted to diagnose the issues related to the chain capacity and competitiveness. However, other regulatory issues and industrial policies are important to the goals and requirements of Local Content.

IBP is supporting ministerial levels, responsible for public policy formulation, to shape an industrial policy to bring the industry's development in harmony with the requirements of Local Content. It is necessary to transform the E&P investors into nationwide supply chain industry backers.

The Brazilian scenario gives its oil and gas industry the possibility to develop a structured sustainability program, based on integrated actions that mirror the international market trends: diversification, conservation, sharing, contention and compensation.

- **a) Diversification –** companies in this sector have tended to diversify its business and product range to become increasingly energy companies. Highlighted, for example is the recent association of Shell with Cozan forming the Raízen bioenergy company, or the very creation of Petrobras Biocombustível.
- **b) Conservation –** such practices tend to grow when faced with problems of scarcity, seeking to reduce supply risk. New refineries should follow advanced practices of water reuse; the existing plant should also evolve towards greater rationalization of water use and energy. Initiatives involving effluent treatment and utilization, in particular the water produced in E&P also deserves attention, seeking, for example, the possible unification of modules or reuse with other parts of the operation or with external activities.
- **c) Sharing –** sharing activities geared to sustainability has good potential to guide the industry's actions, seeking synergies with consequent economies of scale, reduce costs and improve the image. This would give, through increased cooperation at each stage in the production chain, optimizing consumption, generation and treatment/disposal of effluents and waste, to promote synergies among stakeholders and other potential agents. The reduction of waste generation has also merited particular attention from the industry, and the issue has gained new momentum in Brazil with the enactment of the Política Nacional de Resíduos Sólidos – (National Policy for Solid Waste).
- **d) Contention –** another action with great potential that also presupposes the sharing and developing of strategies to prevent and respond to environmental contingencies. The pre-salt perspective, combined with the country's already expressive E&P activity, requires a substantial strengthening in this area. This could be in terms of technologies and processes development to prevent and contain spills, particularly in deep water, or in terms of logistics, planning and management to respond to incidental events. These last activities can be shared between companies that operate in the country through the already defined by legislation area plans.
- **e) Voluntary Compensatory Policies –** in addition to raise the industry to greater acceptance by the market and society and a significant gain of image, the development of compensatory strategies increasingly consistent and continuous has a significant potential to lever new opportunities related to the green economy and the generation of new jobs in this area. A very expressive example of that window of opportunity is the Petrobras Environmental Program, which invests significant resources to support projects aimed at environmental conservation and preservation developed by non-governmental organizations. The program, which prioritized the topics "Water" and "Climate" between 2008 and 2012, financed with R$ 78 million, 44 projects in the last public selection.

SECTION II

BIOFUELS: THEIR CONTRIBUTION TO A GREEN ECONOMY

The conditions of well-being and the ability to produce goods and services in the modern world were based on the abundant supply of energy resources, obtained mainly from fossil sources such as coal and oil. In recent decades, for strategic, economic and environmental imperatives, this energy model has been going through a clear evolution, with the progressive incorporation of renewable sources. Nevertheless, the world energy matrix remains with this profile (fossil sources are responsible for 71% of world primary energy supply), and for a few decades fossil based resources should continue, with an increasing contribution, but still relatively marginal of other energy sources in most countries.

In the Brazilian context, due to the existing resource base and the energy system evolution, the situation is different: in Brazil about half the energy supply comes from renewable sources, with an emphasis on bio-energy and hydroelectricity. The world average is 13%. In OECD countries, this value is even smaller (7%), while in countries outside the OECD it is slightly larger (18%)[8].

In aggregate terms, the per capita energy consumption in Brazil is still well below that of OECD countries (1.33 against 4.52, in 2008), even lower than the world average and that of countries such as China and Russia.

Future scenarios suggest that countries outside the OECD, including Brazil, will be responsible for most of the additional global energy consumption, due to the expectation of economic development in these regions. The successful Brazilian experience with biofuels, with the regular employment of ethanol mixes since the thirties and pure hydrated ethanol since 1979, indicates the importance of the logistics chain for the biofuel program consolidation. This aspect, not always sufficiently highlighted, is crucial: without a cooperative and convergent stance in the distribution chain, storage and resale, producers will not routinely and efficiently reach the consumers. On the contrary to the Brazilian framework, in several countries, which have the right conditions to develop a sustainable market for biofuels, the absence of a cooperative arrangement along the logistics chain has been one of the main obstacles. This situation confirms how the integration of the energy industries based on oil and bio-energy is positive and constructive and offers strategic and economic advantages to both the industries and society.

The Brazilian oil and gas industry shares the sustainable development vision, through actions with results in the medium and long term. It is a full partner of this vision, providing the energy to sustain economic growth, continuously considering its social and environmental impacts and, to meet current global energy needs, is committed to produce energy through secure, reliable and efficient operations, which are environmentally and socially responsible. The industry reaffirms its commitment to leverage more sustainable energy source development to address the risks of climate change and other environmental and social impacts – now and in the coming decades. Biofuels are key elements of this strategy.

8 Report "ENERGIA E A ECONOMIA VERDE - CENÁRIOS FUTUROS E POLÍTICAS PÚBLICAS (Energy And The Green Economy - Future Scenarios And Public Policies). FEDERAL UNIVERSITY OF RIO DE JANEIRO, Alberto Luiz Coimbra Post-Graduation and Engineering Research Institute - COPPE, Programa de Planejamento Energético, PPE/COPPE/UFRJ (Energy Planning Program). AUTHORS: Roberto Schaeffer; André Frossard Pereira de Lucena; Alexandre Salem Szklo; Bruno Soares Moreira Cesar Borba, Larissa Pinheiro Pupo Nogueira, Régis Rathmann, Rafael Soria..

6 CONTEXTUALIZATION OF THE BIOFUEL INDUSTRY

The Brazilian Government has given special priority to the industry, through the national policy on biofuels. This is evident in the biofuels' share of the Brazilian fuel market, translated into objective indicators: in 2010, ethanol and biodiesel production amounted to 27.1 million toe[9] (93% ethanol and 7% biodiesel), equivalent to 542 thousand bpd, or approximately 27% of the current domestic oil production, a considerable volume in absolute and relative terms (EPE, 2011).

The agro-energy industry development has occurred so well articulated within the oil industry, and not in a climate of dispute, but more in an environment of cooperation and opportunity development (Szklo and Schaeffer, 2006), in that they share the same logistic systems and wholesalers, and reached the latest fuel specifications by mixing renewable and conventional components. Also it is notable that relevant commercial agents are acting in both sectors, the example of Petrobras, Raizen Group (Shell and Cosan) and BP.

The singular experience of Brazil presents an introduction and integration of biofuels in the energy market, with interesting results. Even in 1931, practically at the beginning of transport motorization in our country, the compulsory blending of ethanol in gasoline was adopted, later reinforced by the National Alcohol Program in 1975, which increased the ethanol content in gasoline and also pure ethanol came to be used in vehicles. More recently, biofuels have expanded to the diesel market, with the compulsory adoption from 2010 of a 5% mixture of biodiesel. Thus, biofuels are marketed in all retail fuel service stations in Brazilian territory and used, without exception, by all motor vehicles that run on the roads. There isn't a similar situation in any other country.

9 TOE – Tons of Oil Equivalent.

So, due to its relevant and structural presence in the Brazilian energy matrix, it is essential to include the liquid biofuel contribution when considering sustainability aspects and development prospects of a green economy within the Brazilian fuel market.

The contributions of sugarcane ethanol and biodiesel are contextualized next, with a socio-environmental and economic characterization of the agro-industry. Here are highlighted the economic and socio-environmental settings that affect the industry, business practices geared to sustainable development (particularly from 1992 to 2011) and the industry challenges and opportunities on the road to sustainability. Finally, more general comments and conclusions are presented, including comments on distribution stages and the use of biofuels.

7 ECONOMIC AND SOCIAL-ENVIRONMENTAL REGULATIONS THAT IMPACT THE ETHANOL INDUSTRY

7.1 Evolution and current scenario

Ethanol production and use for energy purposes has been developed in Brazil since the beginning of the last century, with the first tests and demonstration programs led by the Experimental Station of fuels and Ores, the current National Institute of Technology. From that experience, in 1931 the Federal Government issued Decree N° 19,717, determining the compulsory blending of ethanol (then called engine alcohol) in petrol on a minimum level of 5% and, between 1930 and 1975, the average content of ethanol in gasoline consumed by Brazilian vehicles ran around 7.5% (BNDES, 2008).

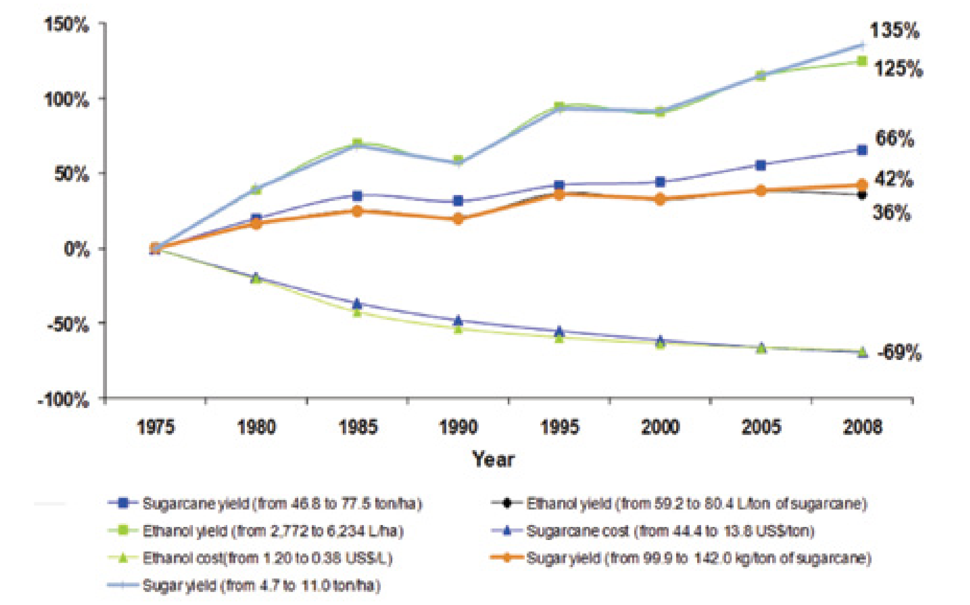
With the National Alcohol Program (Proálcool), created in 1975, this technology received a decisive boost with the opening of credit lines for the construction of production units, the establishment of a favorable pricing matrix, support for technological development and the definition of a guaranteed market, initially increasing the anhydrous ethanol content in gasoline and since 1979 with the use of pure hydrated ethanol engines manufactured or adapted for this biofuel.

Under such stimuli, not only the production capacity expansion and the ethanol fleet of vehicles were notable, but also a significant evolution of industrial and agricultural productivity indicators. Between 1975 and 2005 the agro-industry productivity increased on an average annual cumulative rate of 3.5%, promoting relevant production cost reductions, as shown in Figure 24, revealing an effective trajectory along a learning curve (Goldemberg et al., 2004). As a result of this evolution, the area currently dedicated to sugar cane production for energy purposes is considered only about 3.6 times less than that which would be required if the high productivity rates observed in the seventies had been maintained (BNDES, 2008).

An indicator that pretty much sums up the energy efficiency achieved by sugarcane ethanol production chain is the relationship between production and consumption of fossil energy in the agro-industry, considering the direct forms (excluding solar energy) and indirect (supplies and equipment) of energy consumption. This indicator's average value for production units the Center-South of Brazil, is around 9.2 (Macedo et al., 2008), well above that in all other liquid biofuels production routes, typically between 1 and 3 (Gnansounou et al., 2005).

If biofuels are employed in agricultural operations replacing diesel and in the raw material transportation from the cane plantations to the distilleries, an even better performance is expected, with up to 15 renewable energy units produced per unit of fossil fuel energy consumed in agro-industrial system (Nogueira, 2011a). This excellent performance in converting solar energy into usable chemical energy results primarily from the use of sugarcane, a vegetable with high photosynthetic efficiency as a raw material, as well as its production and processing in appropriate conditions, low-loss, high nutrient recycling (with the use of filter cake and vinasse as fertilizer) and efficient exploitation of co-products, highlighted by the use of bagasse to meet the agro-industry energy demand, generating surplus electricity for the public network.

FIGURE 24. EVOLUTION OF PRODUCTIVITY AND COST INDICATORS FOR SUGAR CANE ETHANOL PRODUCTION IN BRAZIL FROM 1975 TO 2008



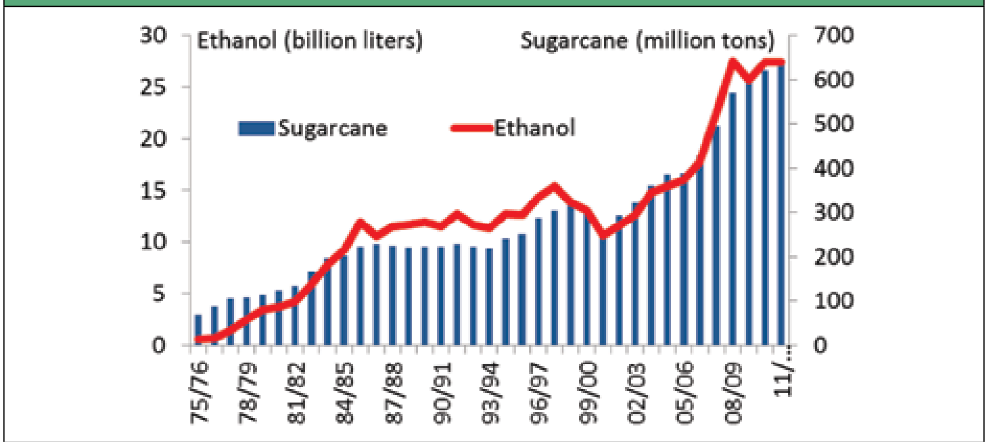
Source: CORTEZ, 2011.

Under such conditions, ethanol use expanded with interspersed periods of increased growth and relative stagnation. As shown in Figure 25, the Proálcool initial step, from 1975 to 1985 saw remarkable growth of ethanol production, due to the process of petrol replacement in the vehicular fleet. From 1985 to 2001, the downturn in support policies led to a consumer interest reduction in hydrated ethanol cars and the biofuel production was maintained primarily for anhydrous ethanol consumption used in the gasoline mixture. During this period the hydrated ethanol vehicles fleet gradually downsized. With the successful introduction of flex-engined vehicles into the Brazilian market in 2003, hydrated ethanol use once again grew and surpassed gasoline. However, the discontinuity, in 2008, of public policies related to ethanol and other adverse factors stagnated the growth of this agro-industry.

Despite this, sugar cane ethanol production and use in Brazil currently represents the most important renewable energy program worldwide, providing the equivalent of 930 thousand barrels of oil per day, considering the production of liquid biofuels and electricity in power plants (MME, 2011). Considering the latest harvests, the Brazilian sugar-alcohol industry annually generates a US$ 50 billion market, involving 434 industrial units and approximately 70 thousand cane producers, providing 1,340 thousand direct jobs and accounting for 18% of the internal energy supply, as such, the second most important source of energy in the country, surpassed only by petroleum (Jank, 2011).

With the marketing of flex-engined vehicles, currently about 50% of the Brazilian fleet of light vehicles (27 million cars in 2010), is prepared for hydrated ethanol consumption, while the rest of the fleet uses gasoline with 18% to 25% of anhydrous ethanol.

FIGURE 25. EVOLUTION OF SUGAR CANE AND ETHANOL PRODUCTION IN BRAZIL



Source: ÚNICA, 2011a.10

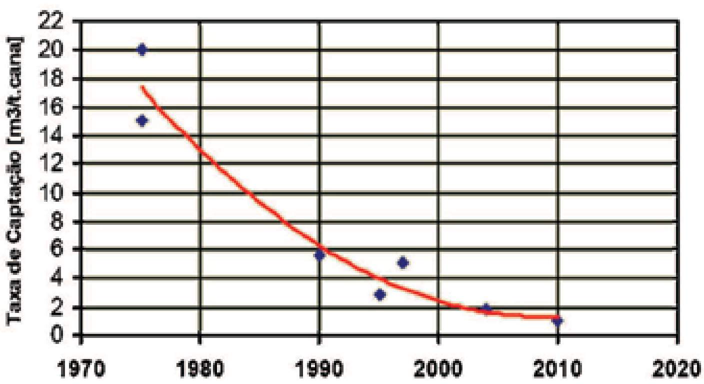
10 Adapted by Luiz Horta.

7.2 Ethanol and sustainability

Sugarcane ethanol provides good sustainability indicators, considering the environmental, social and economic points of view. With regard to the environmental aspects, in terms of emissions of global or local impact, impact on water resources (water use and effluent disposal), use of pesticides and fertilizers, erosion and soil fertility protection and biodiversity, a good number of scientific studies confirm that, in general, the Brazilian sugar cane agro-industry appears in a rational framework, with a favorable evolution associated with the introduction of innovations, while at the same time government agencies are compelling the industry to adopt responsible environmental practices (Macedo, 2005).

As a representative example of improving the ethanol production process, Figure 26 shows the water use reduction in the industrial phase over the last decades, which have dropped from levels around 18 to about 2 m^3 per ton of processed sugarcane (Neto, 2010), as a result of measures to reduce losses, reuse and recycle. There are proposals for power plants without the use of external water sources, employing only the water that constitutes about 70% of the sugarcane culm.

FIGURE 26. EVOLUTION OF WATER CONSUMPTION IN THE INDUSTRIAL PHASE OF SUGARCANE ETHANOL PRODUCTION



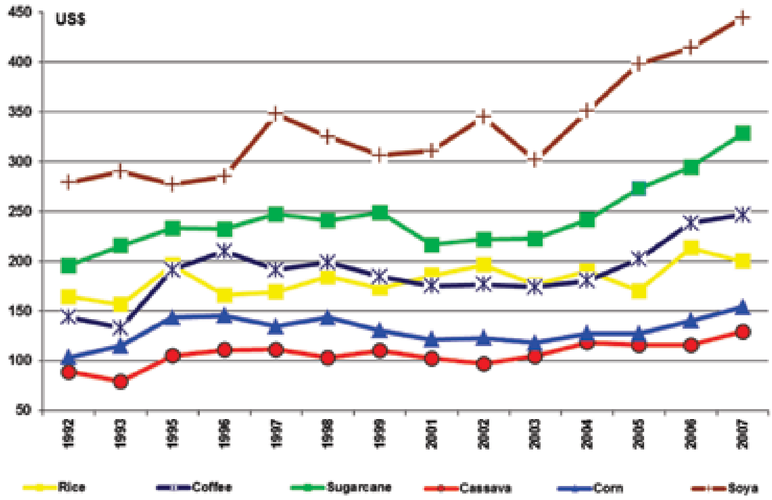
Source: ELIA NETO, 2010.

Among the environmental aspects, it should be noted that the production and use of ethanol has a direct impact on GHG emissions in the transport sector and, recognizing this potential, the national plan for climate change explicitly recommends closer involvement of ethanol in the energy matrix and indicates that the use of ethanol fuel, from 1970 to 2007, avoided 800 million tons of CO_2 emissions into the atmosphere (PNMC, 2008). In view of the sugarcane ethanol consumption in Brazilian vehicles in 2010, (16.2 billion liters of hydrated ethanol and 7.1 billion gallons of ethanol) (MME, 2011) replaced 17.8 billion gallons of gasoline. Considering the gasoline emission factors (IPCC, 2006), the mitigating factors of GHG emissions associated with the ethanol use (Macedo et al., 2008) and the consumed volumes, it is possible to estimate that in 2010, 44.1 million tons of CO_2 were not emitted due to the ethanol use, representing 33% of total emissions measured in 2005 for the entire energy sector (MCTI, 2009).

As regards social aspects, ethanol production, because of its extensive production chain, is one of the economic activities with a high human labor demand and a significant generator of employment opportunities. According to the Relação Anual de Informações Sociais (RAIS) do Ministério do Trabalho (Annual Statement of Social Information from the Ministry of labour), in 2007, 1,283 thousand workers were formally registered in the sugar-alcohol sector in Brazil. Taking into account that 36.5% of these workers were related to ethanol production, this resulted in the generation of 10.9 jobs per ton of oil equivalent produced.

It is also noted that the ethanol agro-industry employment has quality indicators (level of remuneration, educational profile, level of formality, seasonality, etc.) superior to other rural jobs. For example, while less than 40% of rural workers have signed employment documents, in sugarcane farming this percentage exceeds 81% for the national average and is close to 99% in the State of São Paulo (Moraes et al., 2010). One thing to highlight in this context is the strong tendency for mechanization of the sugarcane harvest, motivated by economic and environmental constraints, reducing the personnel demand indicators, but at the same time promoting a higher qualification and wages paid to its employees, which tend to bring wages in line with those paid in the largely mechanized soybean cultivation, as shown in Figure 27. It is estimated that in the 2008/2009 harvest, 37% of the sugarcane was collected mechanically by 1,912 harvesters, while approx. 300 thousand workers performed manual harvesting (CONAB, 2010).

FIGURE 27. SALARIES PAID TO RURAL WORKERS IN DIFFERENT CULTURES



Source: MORAES, 2010.

In the legal and regulatory area, an initiative by the federal Government is highlighted, which seeks to extend and ensure ethanol sustainability: Agro-ecological zoning of sugarcane. By a federal decree, the areas propitious for this culture were assessed, considering soil maps, topography, climate and rainfall rate to classify and delimit the areas with more favorable productive potential, as determined by a minimum level of productivity. At the same time, the current environmental legislation was respected for the areas that needed to be preserved and seeking to reduce competition with the areas devoted to food production.

This zoning, shown in Figure 28, presents in detail the areas suitable for sugarcane cultivation and prohibits sugarcane cultivation in susceptible biomes, such as the Amazon, Pantanal and Upper Paraguay basin, and the expansion of the crop over any type of native vegetation (MAP, 2009). The areas considered suitable for the expansion of sugarcane cultivation total approximately 65 million ha, of which 19.3 million ha are considered with high productive potential.

Currently the area under sugarcane cultivation, around 8 million ha, represents 1% of the national territory. As the agro-ecological zoning indicates that the expansion of this area can occupy 7.5% of Brazilian land, it is clear that “suitable areas are more than sufficient to meet the future demands of ethanol and sugar forecast for many decades in internal and external markets” (MAP, 2009). Reinforcing this assertion, it is interesting to mention that to promote on a global scale a 10% mixture of ethanol in gasoline, in view of the projected demand for 2025 (205 billion liters of ethanol), considering the current technological parameters, it would take about 36 million ha, of course located in several countries, in addition to Brazil (CGEE, 2005).

FIGURE 28. AGRO-ECOLOGICAL ZONING OF SUGARCANE

Source: MAPA, 2009.

Among the aspects related to biofuel sustainability, it is important to highlight the full recognition by other countries in the reduction of GHG emissions in the production chain and use of sugarcane ethanol, as developed in Brazil. After a long process of analysis, in April 2009 the California environmental agency (California Air Resources Board CARB) acknowledged that the use of sugarcane ethanol significantly reduces carbon emissions, being one of the few biofuels that meet the requirements of the Low Carbon Fuel Standard, (LCFS) of that North American State. In February 2010, the United States National Environmental Protection Agency, after protracted studies, awarded Brazilian ethanol the designation of "Advanced biofuel", for its ability to reduce by more than 60% carbon emissions compared to gasoline. This recognition opens an excellent prospect for Brazilian ethanol insofar as this biofuel is one of the few alternatives to meet the demand determined by the United States legislation (Energy Independence and Security Act EISA) and foresaw the increasing participation of advanced biofuels (defined as the Renewable Fuel Standard) in the North American market (EPA, 2011).

The recognition of environmental benefits of sugarcane ethanol by these agencies is certainly a most fundamental step in the process of barrier reductions for this biofuel. Almost paradoxically, in weighing these favorable reviews, international trade in ethanol remains smothered by protectionist measures of potential importer countries, which, with few exceptions, maintain significant tariff barriers.

7.3 Challenges and opportunities for ethanol

Sugarcane ethanol, with almost eight decades of development as a transport fuel, technologically fully consolidated and with a well implemented productive base, constitutes an effective element to develop a green economy in Brazil. The main challenges that remain for the agro-industry energy expansion and full use of its productive potential is the lack of clarity in gasoline price formation mechanisms. This exposes ethanol to a market with prices below the international parity, reducing its competitiveness, and the vague prospects of biofuels in the international markets, still blocked by heavy protectionist barriers that almost do not exist in other energy markets.

Despite the achieved maturity there are interesting possibilities of increasing the agro-industrial productivity, with consequent positive effects on the sustainability indicators, and which are being adopted by the production units. Within the traditional production route frameworks, the more expressive use of biofuels can be highlighted (including ethanol additives in Diesel engines) in the cane production process, the introduction of sugarcane varieties based on advanced biotechnological techniques and the expansion of electricity generation from bagasse and sugarcane harvest residues (which gradually ceases to be burned, as demanded by the environmental agencies). Among the new possibilities under the study for new fuels, are the production technologies of diesel substitutes based on advanced biotechnological routes.

8 ECONOMIC AND SOCIAL-ENVIRONMENTAL REGULATIONS THAT IMPACT THE BIODIESEL INDUSTRY

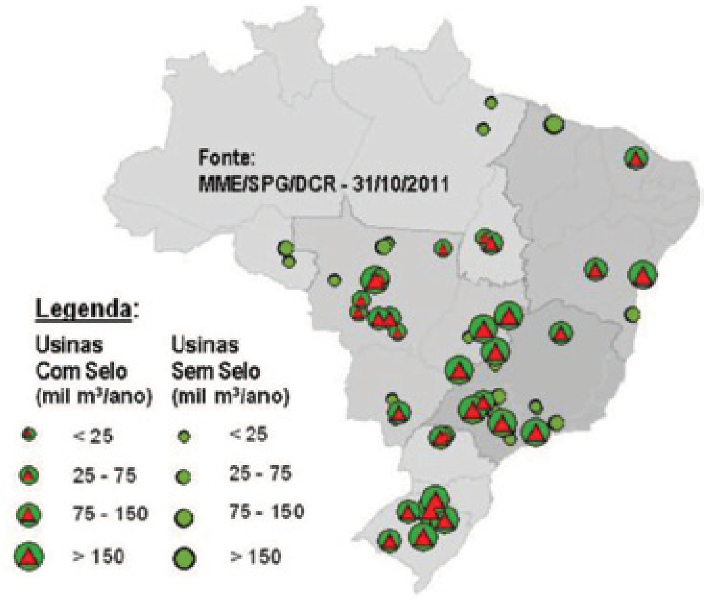
8.1 Evolution and current scenario

Compared to ethanol, the biodiesel framework is quite distinct. It is a biofuel from relatively recently developed technology; the process was patented in the 1950s but is still not widely recognized. On a global scale and in Brazil, biodiesel represents approximately 10% of the total biofuel production. On the production side, biodiesel still has a relative lack of defined raw materials to be adopted, requiring a more complex production process (Transesterification with methanol, using an alkali catalytic converter), and an important aspect, presented by the majority of production routes, its productivity and energy viability indicators signal the need for improvements. Already with regard to vehicular use, at levels up to 10% (and possibly even higher), biodiesel, with ethanol, can be stored and distributed in the normal supply chain and used in conventional engines. It can therefore be considered a direct biofuel market entry ("drop-in biofuel"), without requiring adaptations in the engines, which certainly is an advantage.

In the Brazilian case, with a primary focus more on social inclusion and regional development than as an energy program, was released through law Nº. 11.0972005 Programa Nacional de Produção e Uso de Biodiesel (PNPB), (National Biodiesel Production and Use Program) defining increasing levels of compulsory blending of biodiesel with diesel distributed to Brazilian service stations. Since January 2010 (anticipating the initial goal of 2012), the content of biodiesel in diesel was 5%, ensuring an annual demand of about 2.4 billion liters. This favorable setting, with guaranteed future prices and defined demand in auctions, spurred a rapid installed capacity expansion, which by October 2011 had reached 6.03 billion liters/year from 58 refineries, about 2.5 times higher than the planned annual demand. The raw materials employed are mostly soybean oil (83%) and the beef tallow (13%) (MME, 2011 and ANP, 2011).

Biodiesel production units, as shown in Figure 29, have concentrated in regions with higher availability of soya, the main raw material. Thus, 40% of the biodiesel production capacity is located in its Central-West region, which reflects a similar proportion with the biofuel supply. (MME, 2011). The biodiesel production decentralization in relation to larger Southeast region markets, has motivated not only the development of agricultural activities dedicated to the raw material supply for biofuel production, but also has promoted activities in the remaining production chain links, downstream and upstream of the agro-industrial process, which is a positive consequence.

FIGURE 29. SIZE AND LOCATION OF BIODIESEL PRODUCTION UNITS IN BRAZIL



Source: MME, 2011.

8.2 Biodiesel and sustainability

In the case of biodiesel, the sustainability indicators largely depend on the raw material used. In the most prominent crops, soybeans, castor and palm oil, the agro-industrial productivity is 600, 800 and 5,000 liters/hectare respectively. The energy balance is unattractive for soy and castor and much better for palm oil, confirming the low suitability for those first two crops for energy production. Regarding the price, it should be noted that castor oil is highly valued, therefore not advisably used as a fuel. In the case of tallow, a lower value byproduct of the beef industry, its use in the biodiesel production is interesting and this has been widely used in Brazil, approximately half of the annual supply of 700 thousand tons (Nogueira, 2011b).

With respect to GHG emissions, considering the reported 2010 biodiesel production of 2.4 million m^3 (about 5% of consumption being diesel, 46.2 million m^3) (MME, 2011) – and assuming the estimated mitigation factor for biodiesel production in Brazil – 71% (Nogueira, 2008) the PNPB indicated that year a reduction of 5.3 million tons of CO_2 equivalent, corresponding to almost 4% of total measured emissions in 2005 for the entire energy sector (MCTI, 2009).

Considering the twenty ANP promoted auctions since 2005, the average biodiesel price was R$2.42 /liter (ANP, 2011), well above the price (without taxes) of the replaced diesel, meaning an overall additional cost of approximately R$ 3.6 billion, absorbed by the diesel consumers and by the tax waived by the Union and its Member States. It is worth mentioning that the impact of soybeans biodiesel production on diesel importation is tempered by the high energy consumption of this culture.

As regards social aspects, mechanisms designed to promote subsistence farming in the segment, like the Selo Combustível Social (Social Fuel Seal), are still short of desired levels, since small producers still have limited participation in the biodiesel chain, despite the program high costs and the commitment of the Ministério de Desenvolvimento Agrário (Ministry of Agrarian Development) to incorporate more families in this program.

At the PNPB launch, the goal was to benefit 348 thousand rural families by 2011, but by the end of 2010 it was estimated 100 thousand families were effectively involved, mostly linked to Petrobras Biofuel Programs, the company that represents approximately 10% of biodiesel production (Biodiesel BR, 2011). Thus, with some exceptions, biodiesel production in Brazil, in its current format, still shows limitations in terms of sustainability, particularly in social and economic aspects.

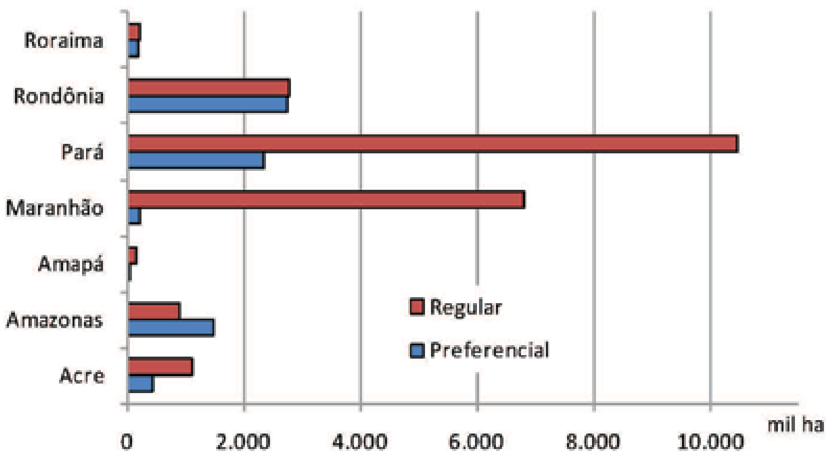
It is important to mention that the Government recognizes these limitations and has introduced adjustments and promoted other raw materials, mainly the palmaceae, with promising results, but it will only become evident in a few years (EMBRAPA, 2011). In this connection, the Programa de Produção Sustentável de Palma de Óleo no Brasil - DENDEPALM (Sustainable Palm Oil Production Program in Brazil) should be highlighted, launched by MAPA in 2010, oriented towards those areas apt for this culture, encouraging the development and diffusion of modern production and processing technologies, involving the creation of a Sectorial Chamber of Palma and the establishment of specific lines of credit, enhancing productivity and sustainability.

Aligning itself to properly redirect biodiesel production in Brazil, promoting raw material production of greater productivity and lower demand for natural resources, the Zoneamento Agroecológico do Dendezeiro – (Agro-ecological Zoning of Palm Oil) was launched in May 2010, also established by Federal Government Decree. This work considered two technological management levels of this culture: level B, employing agricultural practices that reflect a medium state of the art technology, with modest application of capital and modern technology and limited use of mechanization, and level C, considering the adoption of a high technological level, intensive capital application and mechanization present in the various stages of the agricultural operation. Taking into account the eco-physiological requirements of this palm and the environmental offer in pedologic terms, climatic and topographical as well as excluding the legally and environmentally protected areas, 232.8 million ha were analyzed and certain areas declared suitable for each level of management, classified in preferential, regular and marginal areas.

For the management level B, conservative, 29,684 thousand ha were estimated to be available in preferentially apt areas (25%), regular areas (75%), within the Amazonia Legal (Legal Amazon) framework, representing 5.9% of this Brazilian region (MAPA, 2010). The distribution of these areas among the states is shown in Figure 30, where the greatest concentration in the states with the largest fraction of man occupied areas until 2008, are highlighted.

The Amazon deforested area is estimated at 70,407 thousand ha, about 13.9% of the total area and nearly 2.4 times more than the area with favorable prospects for the cultivation of palm oil. Whereas the management level C, with greater technological intensity, due to the demands for increased mechanization, the Amazon area can be reduced by 2.5% and extended to include other States (Alagoas, Bahia, Pernambuco, Sergipe, Espírito Santo and Rio de Janeiro), however in less expressive areas, which total approximately 2.85 million ha in those States. In summary, this study confirms the existence of large areas with potential for biodiesel production on a sustainable basis.

FIGURE 30. AREAS SUITABLE FOR PALM OIL CULTIVATION IN THE LEGAL AMAZON REGION



Source: MAPA, 2010.

Recognizing the opportunity and the biodiesel production potential on more consistent bases, there are important investments to establish palm crops in Eastern Amazonia (Pará e Maranhão), marked out by Ecological Palm Oil Zoning and involving companies such as Petrobras and Vale, aimed at the domestic market and biodiesel exports.

Also seeking to strengthen the biodiesel program, EMBRAPA Agro-energy, through the PROPALMA Program, launched in 2010, has promoted agronomic research on palmaceae oleifera with potential for biodiesel production, considering the different Brazilian territory regions and focusing particularly on the babassu, tucuma, inaja and the macaúba, native species with good prospects, but still have only been limitedly domesticated and little known in agronomic terms. Naturally, the results of these initiatives will take some years to appear, but point in the right direction and could mean a positive sustainability evolution in biodiesel production in Brazil.

8.3 Challenges and opportunities for biodiesel

The accelerated evolution of biodiesel production in Brazil in recent years and the current questions and redirection of this program show both the role of stimulus mechanism in building a productive infrastructure, and reinforces the need that studies on the sustainability of technological routes and production chains be promoted *"ex-ante"* for timely governmental decisions.

At any rate, the Brazilian Government strives to strengthen the biodiesel production program, reducing its weaknesses in the current format (for example, by monitoring the employment and Social Seal effects and adjusting the values of the tax deductions associated with raw material purchase from the subsistence farmer scale), and designing and implementing a renewed program, based on more viable raw materials and considering production systems with the most promising scale and technologies.

Of course, new issues should be studied, such as perfecting palmaceae plantations with bigger extensions and the development of logistics chains in these settings. Under such conditions, the biodiesel program can significantly increase its contribution to the expansion of a green economy in Brazil.

9 FINAL CONSIDERATIONS ON BIOFUELS

The production and use of liquid biofuels has remarkably evolved over the last 20 years, consolidating a relevant position in the Brazilian energy matrix and beginning to represent significant energy market fractions in other countries. This development is sustained on the broad base of existing resources, technological development and greater understanding of the role that these energy vectors fulfill and can still further deliver. In this context, one realizes they are an important factor for a green economy, either through their participation in the energy sector, or by their effects on other areas of the economy both upstream and downstream of the agro-industrial process. So it is asked: what can the next 20 years bring to modern biofuels?

According to recent studies by the International Energy Agency (IEA, 2011) and World Energy Council (WEC, 2011), biofuels, particularly sugarcane ethanol and new products still in development, should expand their important contributions to meet energy needs in the transport sector on a global scale, even considering the emergence of new vehicle technologies, such as electric vehicles. Biofuels have advantages over the other alternatives, the fact of being one of the most feasible and effective ways to meet the dictates of climate change in the transportation sector, offering competitive bases to reduce greenhouse gas emissions.

A recurring issue is the existence of a possible conflict between food production and bioenergy. In recent years this topic was the subject of detailed studies, which highlighted the predominant role of prices of conventional energy sources (notably oil) in the formation of prices of agricultural commodities and the marginal role of biofuels in the struggle for natural resources for agricultural production. Nevertheless, particularly considering the changes in the diet of large contingents of the global population in the trend of higher consumption of animal protein, it is crucial that the biofuel production routes emphasize more efficient alternatives, in terms of land use and energy balance. Such limitations reinforce the advantages of sugarcane as feedstock for ethanol production, as currently carried out, or for diesel substitute production still employing bench processes. In short, it is a fact that so far fuels have little affected the availability of food. However, for that not to happen, it is important that they are produced efficiently and sustainably.

The above factors indicate the appropriateness of the Brazilian options and confirm the possibility for the country to be a reference modern bioenergy model to be adapted and replicated in other countries: open technology, economic competitiveness, suitable environmental performance and backed by international sustainability criteria.

It's also interesting to note how the interest in aviation biofuels has been expanding, with several proposals under assessment, demonstration tests and an intense cooperation between biofuel producers, aircraft manufacturers and air transport companies throughout the world. Certainly there are difficulties to overcome, in particular the associated rigid fuel specifications for aeronautical turbines, but the convergence of effort justifies a positive expectation, even though it is still not clear which are the most promising options (Nogueira, 2011c).

Taking into account the Brazil's role in the expansion of the green economy, if the Country maintains and deepens its energy policy in this area, with medium-term goals, strengthening Governmental actions and measures, including tax factors, so as to strengthen ongoing programs, expanding and consolidating its benefits, a very promising scenario is foreseen.

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