

## **Energy and sustainable development in Brazil**

### *Recent developments and outlook*

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- The relatively clean energy matrix, relatively low per capita consumption and the fact that Brazil is an unprecedented example of a country that has achieved a drastic reduction in Greenhouse gas emissions are factors that may discourage critical reflection. We run the risk of not stimulating the identification and proper use of our potential for further advances towards a low-carbon economy.
- In principle, there is no contradiction between exploiting the deepwater oil reserves (pre-salt) and the commitment towards a low-carbon economy, if the intelligent management of royalties and production strategies is guaranteed. Furthermore, investments in second-generation ethanol, with a greater technological content are needed and the exploitation of the pre-salt has to be accompanied by an expansion of the technological capacity. The income generated this way could be channeled to foster structural reforms in the fields of education and social infrastructure and to contribute to the transition to a low-carbon economy.
- It should be acknowledged that the expansion of the electrical system will come about from other sources. After all, if in the recent past, there was a justification (albeit questionable) regarding the role of thermal plants fueled by diesel and coal on a stand-by regime. This changes when we speak of reorganizing the matrix. In this new context, the use of thermal plants would be gradually reduced to zero and replaced by Eolic, bioelectricity and solar power.

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## Introduction

The intention of this study is to analyze Brazil's potential in the global effort towards a low-carbon economy, highlighting the interfaces with energy policies. Brazil's track record stands out in this field, as it currently possesses an advantage vis-à-vis other countries. Besides having a comparatively clean matrix, it has shown the capacity to advance a significant reduction in Greenhouse Gas emissions (GHG)<sup>1</sup>. On the other hand, these achievements might be demotivating further advances that are required.

The climate change issue has given way to the need of seeking alternatives to fossil fuels for reasons other than those of their depletion. The 4th Intergovernmental Panel on Climate Change (IPCC) from 2007 can be deemed an important turning point because of the impact caused by the statement on global climate change as “very likely” being influenced by human behavior. Under the influence of the Report, in 2008 the Brazilian government drafted the National Plan on Climate Change (PNMC-Política Nacional sobre Mudança do Clima), an action plan that should not only coordinate the activities of different agencies at the federal sphere but also articulate them with states and municipalities. The following year, at COP<sup>2</sup> 15, in Copenhagen, through a turnaround of the Brazilian stance, the government took on voluntary

national commitments with goals to reduce emissions, in the range of 36.1% to 38.9%, compared to its projection for 2020 (base-year 2005)<sup>3</sup>.

These voluntary national commitments were included in the coding of the National Plan on Climate Change (Act 12.187 from December 29, 2009). The legislation set up Sectoral Plans for Mitigation and Adaptation to Climate Change. In 2011 and 2012, Sectoral Plans were drafted in the fields of Industry, Mining, Transportation/ Urban Mobility and Health.

The law sets forth that in order to comply with the voluntary national commitments, the following is required:

Expansion of the hydroelectric power supply, supply of alternative renewal sources, markedly windmills, small hydroelectric plants and bioelectricity, supply of biofuels and an increment in energy efficiency.

As a counterpoint, there was the inevitable resistance on the part of those economic sectors directly involved, faced with the risk of losing their competitiveness vis-à-vis international players. In transitioning to low-carbon economy, investments have the potential to mitigate the negative impacts of climate change as well as save costs in the mid and long term. The problem is that in the short term, in the absence of mandatory duty or international coordination, there will be a cost increase. Confronted with such possibility, the industry has shown concern about a conflict between international competitiveness and its investments.

An example of the political stance that gained strength after 2008, with the global crisis, was the publication of a joint communiqué of the employer associations and unions of the chemical industry in Germany criticizing the concept of *Energiewende*,

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1 Greenhouse Gases are: carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), hydrofluorocarbons (HFC) and perfluorocarbons (PFC).

2 The Conference of the Parties (COP) is the supreme decision-making body part of the Convention on Biologic Diversity (CBD), a United Nations Treaty (UN) fruit of ECO-92 – The United Nations Conference on Environment and Development (UNCTAD), held in Rio de Janeiro in June of 1992. The first four meetings of the COP were held annually. Beginning with the fifth meeting, COP started meeting every two years. This is a large meeting, with the participation of official delegations from the 188 member of the CDB, 187 countries and the European Union, observers from non-participating countries, representatives from international bodies, academic organizations, non-government organizations, organizations of entrepreneurs, indigenous leaders, the press and other observers.

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3 Up to that time, the position that predominated was that the entire responsibility to reduce emissions fell upon developed countries, and therefore, there was opposition, along with the other countries of the G77+China, to any commitment towards reduction in the rate of emissions and on the part of developing countries.



a word in German that expresses the necessary revolution in the energy matrix to combat climate change. They argued that alternative energies, particularly wind and solar energy, would not provide reliable supply of energy to the industry; and above all, that this policy would make the German industry less competitive<sup>4</sup>. That same year, in Brazil, The Confederation of Industries (CNI - Confederação da Indústria, 2010) expressed similar concern about the impact on competitiveness of domestic commitments, generating additional costs, while other countries do not implement the same measures.

Last but not least, there is the technological issue related to the existence or nonexistence of an endogenous capacity, that is, the national power to master and develop such technology, allowing the country to be permanently at the forefront of research regarding the discovery of new sources and a more efficient use of existing ones. This endogenous capacity demands qualified labor. The alternative would be reliance on technology from abroad.

### 1. Differentiated energy matrix

The result of efforts to ensure growth conditions, without external constraints, has led to a Brazilian energy matrix that stands out in comparison with its international counterparts. Although efforts in the field of ethanol and hydroelectricity were not initially spurred by the desire to generate a low-carbon matrix, it did lead to the latter. What seemed to be a curse led to triumph: the scanty existence of coal and the relative delay in discovering and exploiting oil in large volume led to such scenario.

Table 1 (Page 4) shows the relatively high weight of renewable sources in the Brazilian energy matrix. Thus, while the worldwide energy matrix presents 81% share of fossil fuel, in Brazil this share is of 53%. For renewable sources, the share reaches 45% in Brazil, compared to 13% worldwide. In the case of the electrical energy matrix, the difference in Brazil becomes even clearer, as shown in Table 2.

4 Available at: <<http://www.igbce.de/download/7622-15978/1/xvi-26-25-09-2012-energie-wende-gestalten.pdf>>.

	World	Brazil
Oil	32%	37.5%
Coal	28%	5.3%
Natural Gas	21%	10.3%
Nuclear	6%	1.4%
Hydroelectric	2%	14.1%
Sugar-cane by-products	0%	17.5%
Others	11%	13.9%

Sources: Secretary of Energy Planning and Development from the Ministry of Mines and Energy.

	World	Brazil
Oil	41%	1.3%
Coal	22%	5.7
Natural Gas	16%	74.3%
Nuclear	13%	2.7%
Hydroelectric	5%	2.7%
Sugar-cane by-products	0	5.1%
Others	3%	8.2%

Sources: Secretary of Energy Planning and Development from the Ministry of Mines and Energy.

In this case, the fossil fuel sources account for 68% of worldwide supply, compared to 10% in Brazil, due to the domestic use of renewable sources that reach 86% compared to only 18% globally.

Up to the present, Brazil is the only country where ethanol (hydrated) is sold as fuel with no gasoline mixture. Graph 1 shows the upsurge of the ethanol production capacity during the last decades. Additionally, ethanol (anhydrous) is mixed with gasoline. The Brazilian government announced in mid-2014 its intention to increase the mix of anhydrous ethanol in gasoline from 25% to 27.5%. Above this amount, engines would have to be upgraded. Over 40 countries, including the United States and China,



also use this mixture, albeit in proportions that tend to be 5% or 10%.

Brazil has consolidated itself as the second consumer market for biofuel, second only to the United States, as can be seen in Table 3.

	2005	2010	2012
USA	337.941	1.012.973	1.070.660
Brazil	291.533	588.900	517.495
Germany	81.259	123.947	120.873
World	777.604	2.377.504	2.498.871

Source: PBL Netherlands Environmental Assessment Agency/ European Commission (2013)

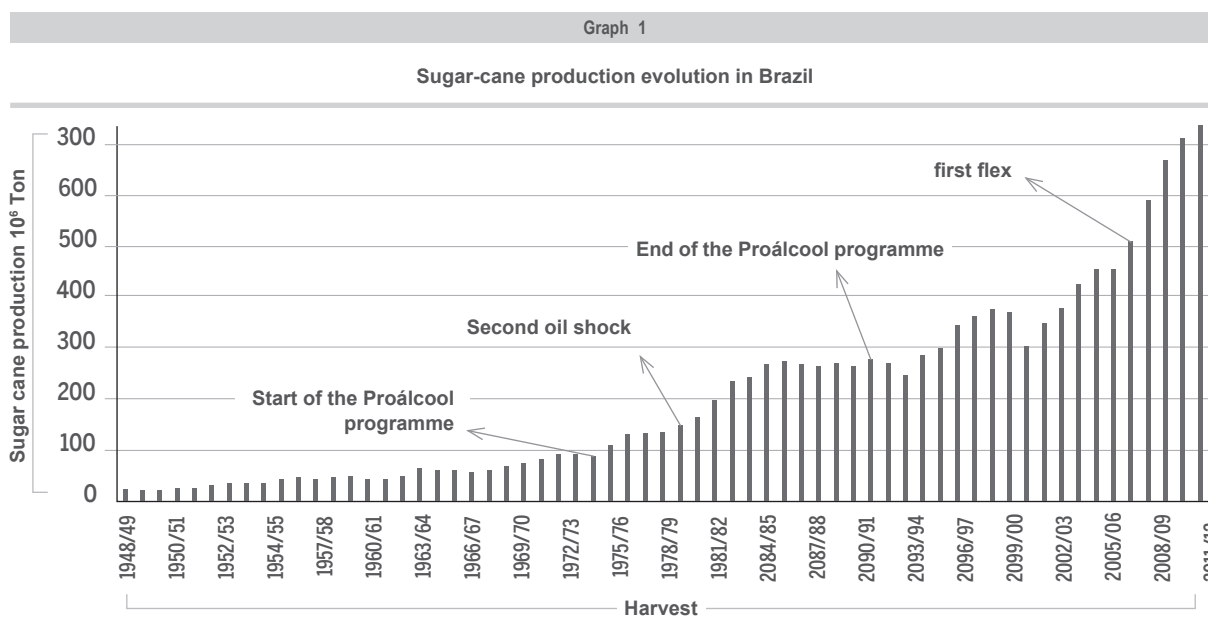
In 1939, the hydroelectric energy installed capacity was recorded at 884 MW. Under state control, this capacity expanded to reach 80.600 MW in 2010. The milestone came in 1984, with the operations kick-off of bi-national dam Itaipu ten years after the beginning of its construction. At that point in time, Itaipu was the largest hydroelectric plant in the world, with a capacity of 14.000MW.

Renewable energy is also a source of employment generation. Data from the Annual 2014 Report on the levels of employment generated in the country for renewable energies, from the International Renewable Energy (IRENA) show a global figure of 6.5 million, with Brazil ranked second (see Table 4).

Country	Number of jobs
China	2 million
Brazil	894 thousand
USA	625 thousand
India	391 thousand
Germany	371 thousand
Total World	6.5 million
11%	13.9%

Source: Irena (2014)

Brazil stands out in terms of jobs generated in the bioenergy sector: 621 thousand, followed by 32 thousand in the wind chain. However, we must point out that despite being an intergovernmental organization, Irena heeded the criticism from part of the non-government organizations regarding



Source: Department of Agrarian and Environmental Sciences (DCAA) from the State University of Santa Cruz; SPAE; Sugar-cane Industry Union (Unica) and Ministry of Agriculture, Cattle Raising and Supply (Mapa); Union of Bioenergy Producers (UDOP). Data regarding the 2010/2011 and 2011/2012 harvests (estimates) are from the National Supply Company (CONAB). My own draft.



the large hydroelectric projects and excluded hydro power from its calculation. Had this not happened, the number of jobs accounted for in Brazil would be higher, but would not surpass China, which tops the ranking. China's leading position can be explained largely due to the labor employed in equipment production for solar and wind energy.

### 1.1 Low-carbon matrix with great emissions?

In theory, Brazil's distinguished matrix would have yet another reason to be in the limelight, with the world focus on Greenhouse Gas emissions (GHG). But this was not the case at first, due to another aspect of the Brazilian reality, i.e. the burning of large areas, mainly in the Amazon Forest, as part of the savage logic for the expansion of agricultural land, especially soybean and meat production, besides timber itself. For many years they were, by far, the main source of GHG emissions. This is to say that the low-carbon energy matrix was hidden behind the smoke screen of the burning process. The First Brazilian Inventory of Anthropogenic Greenhouse Gas Emissions was published in December of 2004 and referred to the 1990-1994 period<sup>5</sup>. The second national inventory (Ministry of Science and Technol-

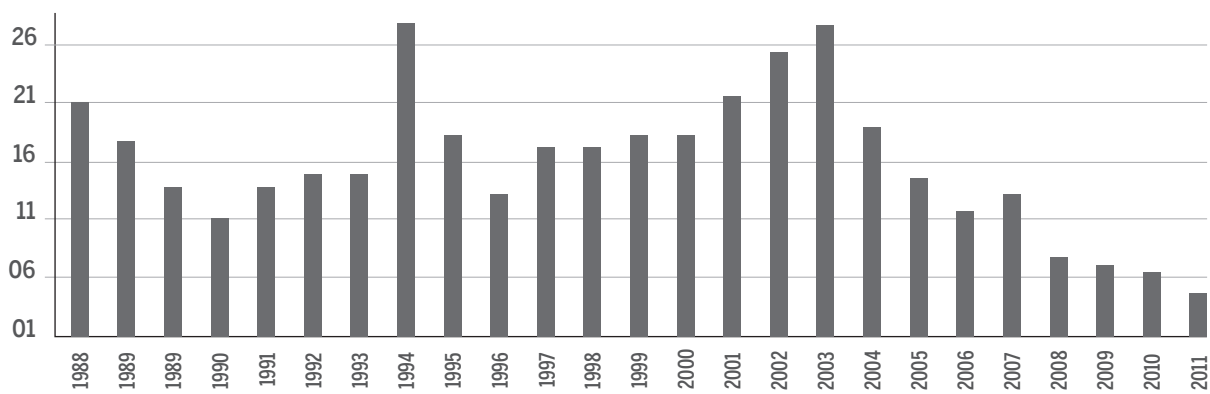
ogy, 2010) referred to the period of 1990-2005, and estimated the participation of energy emissions at 16.48% of the total GHG emissions in Brazil. In the case of deforestation, the estimate was 64.1%. It was precisely in this field that Brazil made impressive progress, a progress little known to the lay public and, above all, undervalued throughout the world, as well as in Brazil (see Graph 2).

Beginning in 2004, through a series of coordinated policies and advanced monitoring carried out by the National Institute on Space Research (Instituto Nacional de Pesquisa Espacial - INPE), Brazil managed to reduce deforestation by an average of 20.000 km<sup>2</sup> between 2001 and 2004 to 12.000 km<sup>2</sup> between 2005 and 2009, and to 7200 km<sup>2</sup> between 2009 and 2010 (see Assunção, J & ea., 2012). In 2004, the government launched an Action Plan for the Prevention and Control of Deforestation in Legal Amazon, a set of measures coordinated by the federal, state and municipal spheres. In 2008, the National Monetary Council (Conselho Monetário Nacional-CMN) published Resolution 3445, banning loans to landowners involved in deforestation. Credit lines for activities in the Legal Amazon were therefore released only upon proof of compliance with the legislation on land and the environment. We must not forget to mention non-government organizations actions, both at the national and international levels, exerting pressure on importing

5 <http://www.mct.gov.br/index.php/content/view/17341.html>

Graph 2

Track record of the deforestation of the Legal Amazon region in 1000 km<sup>2</sup>, 1988 to 2011



Source: INPE



companies in developed countries. Reduction in deforestation brought an end to the myth that we were helpless to control deforestation in the Amazon region, and is now a triumph because of the global carbon sequestration it operates. Furthermore, there is an enormous potential to reclaim degraded areas that were deforested in the last two decades.

The consistent drop in deforestation does not mean that Brazil has reached acceptable levels, much less that there is no need to consolidate and enhance its monitoring capacity. The backdrop is that, with restrictions in the savage expansion, cattle breeders are motivated to organize their expansion through productivity gains and intensification. On that note, the reduction in pasture areas that began in the mid 2000 is noteworthy.

It is necessary to consider that the drop in deforestation, verified at a minor scale at the beginning of the 1990's, coincided with the internal situation of crisis and drop in agro-export product prices associated with deforestation. In this way, the strong drop verified as of the second half of the decade of 2000 draws even greater attention, as it coincides with a phase of expansion in the domestic economy and a strong appreciation of agricultural prices in international markets, especially for meat and soybeans. It also coincides with a strong expansion in ethanol production<sup>6</sup>. Therefore, it is fair to say that we are not dealing with outliers, but with structural change in terms of how this issue was managed, particularly --but not exclusively-- in the Legal Amazon region. Based on this achievement, Brazil was able to present itself as the winner in GHG reductions: -38.7% in the period between 2005 and 2010, something unheard of worldwide. The share of burning in the total Brazilian emissions fell from 57.5% in 2005 to 22.4% in 2010, significantly lowering emission standards. In 2012,

6 Ethanol production is concentrated in other areas, especially in São Paulo, but there is a thesis of a purported indirect effect: the substitution of the use of land previously used for soybeans and cattle for sugar-cane plantations. This must have caused a migration of soybean production and cattle raising to areas which involve deforestation. The drop in deforestation does not support this thesis.

Brazil recorded higher GHG emissions coming from the burning of fossil fuels at thermal plants than those caused by deforestation.

The significant advances in deforestation reduction changed the configuration of the GHG sources of emission in Brazil, as can be observed in Table 5. Although the burning still represents an important factor in GHG emissions, the main emitting activities today are cattle raising and energy.

**Table 5**

**Evolution of GHG emissions per source** in Gg CO2 equivalent

	1990	2000	2005	2010
<b>Energy</b> (including transportation)	191.543	301.096	328.808	399.302
<b>Industrial processes</b> (excluding use of energy)	52.536	71.673	77.943	82.048
<b>Cattle raising</b>	303.776	347.878	415.713	437.226
<b>Forests</b>	303.776	347.878	415.713	437.226
<b>Residues</b>	815.965	1.324.371	1.167.917	279.163
<b>Total</b>	28.939	38.550	41.880	48.737

Source: MCT (2013)

According to the World Resource Institute (WRI, 2010), worldwide energy (including transportation) accounts for 64.4% of the GHG, in that for the European Union this same percentage is 77.9% and in the United States 87.1%.<sup>7</sup> Table 6 shows the evolution of energy share in the total GHG in Brazil.

**Table 6**

**Evolution in the share of energy in the total GHG in Brazil**

	1990	2000	2005	2010
	13.7%	14.5%	16%	32%

Source: MCT

7 According to the IPCC classification, the other sources of GEE are: industrial processes (not considering the use of energy); use of solvents and other products; cattle raising; changes in the use of land and forests; and residues treatment.



## 1.2 Relatively low per capita consumption

Another characteristic to be taken into account while analyzing the present and, most importantly, for projections about future scenarios, is the relatively low per capita consumption of energy in Brazil. Table 7 shows per capita energy consumption in Brazil, compared to other countries.

Country	1980	1990	2000	2008	2011
USA	7942	7672	8057	7488	7032
Australia	4737	5053	5645	5766	5501
South Korea	1081	2171	4003	4636	5260
The Netherlands	4549	4393	4598	4837	4638
Germany	4562	4421	4094	4075	3822
Japan	2950	3556	4091	3879	3610
South Africa	2371	2584	2483	2961	2741
Italy	2318	2584	3012	2942	2664
Venezuela	2347	2206	2312	2475	2380
China	847	1060	1629	1801	1940
Argentina	1487	1412	1652	1961	1967
Brazil	935	937	1074	1296	1371

Source: World Bank

Table 8 shows Brazil's cleaner matrix in the international comparison of CO2 emissions.

Although the potential for increased efficiencies is indisputable, one must also acknowledge the fact that Brazil's stage of development leads us to predict elasticity greater than 1 in the growth of energy demand, vis-à-vis the Gross National Product (GNP), as can be seen in Table 9. This means that 1% increase in GDP will cause increase in the energy demand of more than 1%.

Notwithstanding this fact, a cleaner energy matrix, relatively low per capita consumption and setting an unprecedented example in drastically reducing

	Total emissions in millions of t 2012	Per capital emissions in t 1990	Per capital emissions in t 2000	Per capital emissions in t 2010	Per capital emissions in t 2012
USA	5.200	19,6	20,6	17,6	16,4
South Korea	640	5,9	9,8	12,2	13
Germany	810	12,7	10,4	9,9	9,7
European Union	3.700	9,1	8,4	7,8	7,4
China	9.900	2,1	2,8	6,4	7,1
Mexico	490	3,6	3,6	3,9	4
Brazil	460	1,5	2	2,2	2,3
India	1.970	0,8	1	1,5	1,6

Source: PBL Netherlands Environmental Assessment Agency/ European Commission (2013)

	GDP	Electrical energy consumption
2010	7.5%	8.2%
2011	2.7%	4.2%
2012	1%	3.5%
2013	2.3%	3.5%

Source: EPE

GHG emissions in the last few years, may discourage critical thoughts about this issue, instead of encouraging the identification and use of alternatives with higher potentials to further advance towards a low carbon economy.

On the other hand, Brazil has not stopped being the target of vivid criticism, notably from international and national environmental movements, but also from academic sectors. Firstly, for years, the target was the deforestation of the Amazon region. It so happens that the reversal of this situation was not met with equivalent recognition. Quite the contrary, we often hear the same issue being discussed whenever there is an increase in the periphery --





because the drop in deforestation does not take place in a linear fashion. Secondly: ethanol was the target of harsh criticism, because of its supposed social unsustainability (exploitation and super-exploitation of labor); environmental implications (it would necessarily lead to deforestation); and social and economic issues (supposedly, it would push food production out and, hence, it would be the culprit of an increase of prices in the basic food basket). Thus, from being the spearhead of Brazilian contributions towards a low-carbon economy, ethanol found itself on the defendant's bench. The specificity of Brazilian ethanol was not analyzed in comparison to biofuels produced in other environments, and Brazil's capacity to tackle social and environmental problems, which, in the context, are not inherent to ethanol production, but to social and political relations in the sugar-ethanol sector and, therefore, subject to change. Finally, the hydroelectric plants themselves went from being symbols of low-carbon power generation, to villains, for infringing on the rights of indigenous peoples and other communities impacted by the dams. There was even speculation regarding methane emissions (also a GHG) caused by the dams<sup>8</sup>.

Many of these criticisms are legitimate and instrumental in leading to the necessary adjustments or adaptations. However, by not recognizing the advances attained by Brazil thanks to the use of these sources for a growth strategy based on the low-carbon matrix, no constructive dialogue may be held. Both, the lack of recognition of advances made and settling in the position of international comparisons make it difficult to prioritize concrete actions, so that Brazil may effectively affirm its leading position in the global struggle towards a low-carbon economy.

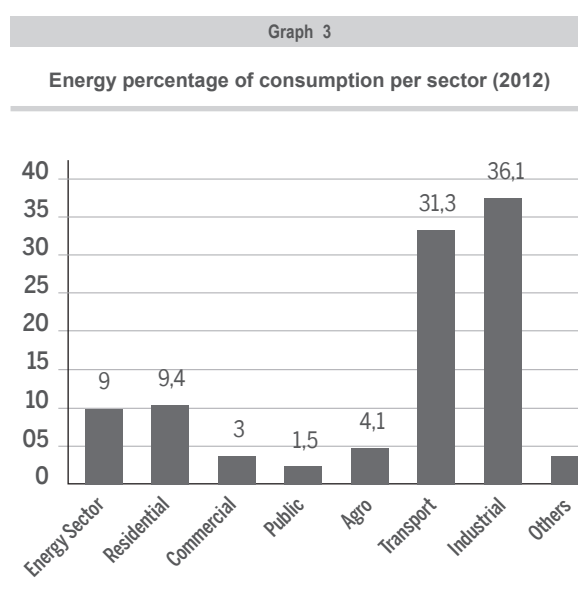
### 1.3 New reality and the transportation sector

There has been a qualitative change with the drop in deforestation; the challenge is different now. As

far as energy is concerned, there was an increase of emissions coupled with economic growth, especially in the transportation industry. This means that, in this new phase, the priority should be to alter the transport matrix, overcoming what currently stands out as peculiarity specific to Brazilian reality: the great share of transports on wheels for cargo. By the same token, another priority is to make up for the lag in finding solutions for mass public transportation, which has not kept up with the strong expansion of the automobile fleet, as of the mid-2000 decade.

The relative drop in demand for electrical energy by the industrial sector, beginning in 2011, reflects the problems experienced by the industrial sectors in Brazil, as for example the relative de-industrialization trend – with low investments in production. This was not the result of efforts to increase energy efficiency. In 2010, the industrial sector accounted for 39.6% of total energy consumption in Brazil, falling in 2012 to 35.1% and, in 2013, to 33.9% (BEM, 2014). Therefore, this endeavor to defend the Brazilian industry, - if successful- should result in an increase in income elasticity/energy consumption.

Already in 2013, GHG emissions in Kg CO2 equivalent had increased 399.302, in 2010, to 459.000 (BEM, 2014). This expressive rise in absolute fig-



Source: EPE/PDE (2013)

<sup>8</sup> The energy sector itself states that there could be a carbon sequestration by reservoirs.



ures and relative numbers on the GHG emissions of the energy sector are due to the transport component, more specifically to cargo (see Table 10).

**Table 10**

**Scenario in the evolution of share of the different segments in GHG emissions of Highway Automotive Vehicles**

	CO		NOx		CO2	
	2009	2020	2009	2020	2009	2020
Trucks/ buses/ commercial vehicles	17%	26%	92%	93%	62%	60%
Light automobiles	48%	51%	8%	7%	35%	37%
Motorcycles	35%	23%	-	-	3%	3%

Source: MMA (2011)

According to data from the National Agency for Land Transportation (Agência Nacional de Transportes Terrestres - ANTT), updated in April 2014, there are 2.106.716 trucks circulating in Brazil, with an average age of 12.2 years. Of these, 947.450 are autonomous trucks at an average age<sup>9</sup> of 16.8 years. For the time being, Biodiesel is added at very low percentages into the mixture (7%).

Regarding the transport sector, there is therefore a stream of challenges: expanding the railroad network; improving the efficiency of motor vehicle engines; improving traffic management; motivating the use of public transportation; intensifying the use of biofuels and the increase of energy efficiency in general. The automobile industry already knows what it has to do to reduce the level of emissions, as they have been implementing these innovations in their countries of origin for quite some time now. Europe, the United States and Japan – countries of origin for most of the car makers established in Brazil - have more stringent rules in this regard.

An important attempt by the Brazilian government to invert this situation was the Program to Motivate Technological Innovation and the Intensification

of the Productive Chain for Automotive Vehicles (Inovar-Auto), part of the industrial policy “Plano Brasil Maior” (literally “Greater Brazil”). The program launched by the government in October of 2012, came into force at the beginning of 2013 and is valid up to the end of 2017. This voluntary program increased taxes on industrialized products (IPI) by 30% for the light vehicles sold between the years 2013 to 2017, granting exemption for car makers who adhere to the program and comply with a series of counterparts. The basic goal is to reach energy savings of 12.08% in automobiles until 2017, compared to the base year of 2011.

The transportation sector accounted for 47% of total of energy sector emissions in 2013, although its relative share in energy consumption is of 32%. Table 11 makes a comparison between energy consumption and the share in GHG emissions in the transportation sector, industry, residential consumption, all referring to the year 2013.

Another factor that explains the increase in GHG emissions in the energy sector is the increase in the use of thermoelectric plants to generate power. This will be dealt with in Section 2.1.

#### 1.4 What about the deep water oil discoveries, also known as Pre-salt?

The massive deep water oil discoveries, announced officially in November of 2007, changed Brazil’s position in the future projections of the global Petroleum & Gas (P&G) market. Brazil may be in a position to substitute its imports and become a

**Table 11**

**Comparison in share of energy consumption/ emissions share / 2013**

	Share in emissions relating to energy consumption	Share in emissions relating to energy consumption	Share in renewables in energy use in the sector consumption
Transportation	32%	47%	17%
Industry	33.9%	19.4%	56%
Residential consumption	9.1%	3.9%	62%

Source: BEM, 2014, our own drafting

9 www.antt.gov.br



broad exporter. In principle, there is no inherent contradiction between exploiting this wealth and the commitment to move forward towards a low-carbon economy. It all depends on how the wealth and exploitation will be managed and on the production strategies chosen. This type of finite wealth can contribute to fund the transition. Some of the risks must be acknowledged<sup>10</sup> in the context of this study, particularly those challenges of not sullyng the matrix, or making biofuels no longer an alternative source – because of the potential of lowering the prices of oil by-products and continuing to invest heavily to increase efficiency in energy use in the transportation sectors.

In the case of the ethanol/gasoline ratio, the most appropriate strategy is to make the most of the ethanol potential to supply the domestic market and follow-up on the growth in demand, investing heavily in second-generation ethanol, with greater efficiency and greater techno content. In addition, pre-salt oil must be intelligently explored, linking the capacity to expand to domestic productive-technological capacity and gearing oil surpluses to foreign markets. The generated income could thus be channeled to overcoming structural deficiencies in the fields of education and social services and also to funding the transition to a low-carbon economy.

## 2 Projecting the future of Brazil's energy matrix

Next we will analyze the situation and the outlook of the different sources of energy in the context of the domestic and international scenarios presented here.

### 2.1 Hydroelectric plants and the expansion of the electrical system

The energy supply problems, which occurred

in 2001 (blackout), led the administration to reflect about the system and ended up giving birth, in 2003, during the Lula administration, to a new model, based on two principles: reinforcing planning, with the creation of the Energy Planning Company (EPE), linked to the Ministry of Mines; and celebrating long-term Energy contracts awarded according to auctions, with a view to provide greater security to investors. Under this new regulatory framework, installed capacity in the electrical sector rose from 90.679 MW to 126.755 MW, between 2004 and 2013.

With this new energy planning, Brazil began to focus on new renewable sources. The concern for social and environmental impacts of hydroelectric plants is also a relatively recent consideration.

The effects of climate change had a dire impact on the structure of hydroelectric plants: the significant variations of water flows represent a reason for concern when it comes to the country's energy security. Such effects have heated up the debate on the government's decision to opt for Run-of-the-river hydroelectric (ROR) plants, instead of using accumulation reservoirs to acknowledge environmental impacts. One of the arguments is that the loss of capacity to regulate the reservoirs forces the electrical sector to activate the thermoelectric plants. The Brazilian Association of Large Industrial Energy Consumers and Free Consumers (Associação Brasileira de Grandes Consumidores Industriais de Energia e de Consumidores Livres - Abrace), for example, advocates for a resumption of the construction of plants with large reservoirs to guarantee energy availability at competitive prices<sup>11</sup>.

In fact, the severe draught at the beginning of 2014 has unveiled the system's fragility. To a large extent, this was also due to the fact that this period coincided with the structural effect of delays in large projects in the North region, more specifically Belo Monte in the Xingu River, that should be launched only in 2015 to begin operating at full capacity in

10 For a global view of the challenges and opportunities of the deep water oil discoveries: Schutte, G.R. Brazil: New Developmentalism and the Management of Offshore Oil Wealth. *European Reviews of Latin American and Caribbean Studies*. N° 95, October 2013.

11 Camila Schoti, coordinator of the Abrace Electric Energy, in the main financial newspaper, *Valor Econômico*, on 3/11/2014 "Com muito bom senso e sem jabuticabas".



2018. The same holds true for the Madeira River plants (Santo Antônio and Jirau).

There are socio-environmental limitations to hydroelectric expansion: 60% of Brazil's remaining hydraulic potential is in the Amazon basin, involving the Tocantins, Araguaia, Xingu and Tapajós Rivers, with a potential impact in the forest reserves, national parks and indigenous lands. Faced with this new reality, the installed hydroelectric plants park has become inadequate. Almost half is composed of low-investment plants with high operating cost at start up. This ratio was adequate in the past, when the regulating capacity of reservoirs was greater, climate instabilities were less prevalent and the thermoelectric plants were set up to operate only in situations of severe draught. However, everything points to thermoelectric plants being used even more intensely in the future. The issue at hand is to know if this means taking a step backwards, so that later we can take two steps forward, with the entry into operation of an adequate capacity of windmills, Small Hydropower Plants (SHP's)<sup>12</sup> and solar plants.

The EPE's ten-year plan projects an expansion based primarily on renewable sources, as we can see in Table 12. Although there is also an increase in on non-renewable sources capacity, the latter would hold as smaller share.

**Table 12**

**Evolution in electric energy installed capacity per generation source**

Source	2013	2018	2022
Renewable	107.397 MW	136.377 MW	157.150 MW
Non-renewable	19.380 MW	24.903 MW	25.903 MW
Hydro	68,5%	66,3%	65%
SHP/Wind/Biomass	14,4%	18,3%	20,8%
Non-renewable	17,1%	15,4%	14,2%

Source: PDE2022, own drafting.

12 <http://www.portalpch.com.br/>

## 2.2 Natural Gas

Among fossil energy sources, gas is unquestionably the best, in terms of energy efficiency and GHG emissions, as seen in Table 13 below.

**Table 13**

**GHG emissions in Brazilian thermoelectric plants 2010 in CO<sub>2</sub>eqkWh**

Country	gas reserves
Mineral coal	1144
Diesel oil	829
Fuel oil	781
Natural gas	518

Source: Miranda (2012)

Until recently, there were no prospects for an increase in domestic production. The novelty is that the pre-salt and other discoveries support not only the exploration and production of oil in large amounts, but also provide for the production of natural gas. This will enable increased use of gas, without an increase in imports.

Table 14 shows an increase in the natural gas supply in the domestic market, mainly due to an increase in domestic production.

**Table 14**

**Projection in gas supply in Brazil until 2030 in millions of m<sup>3</sup>/d**

	2013	2018	2020	Annual average 2021-2030
Domestic production	41	75	86	97
Imports from Bolivia	30	30	30	30
Re-gasification of imported NLG	21	41	41	41
<b>Total</b>	<b>98</b>	<b>146</b>	<b>157</b>	<b>168</b>

Source: Petrobras (2014), own drafting



## Shale gas

Brazil is one of the countries with technically exploitable shale gas reserves, according to data from the IEA and from the United States government. In Table 15, Brazil ranks tenth among the countries with technically recoverable shale gas reserves in the world.

Table 15

Estimates for worldwide recoverable shale gas reserves (2013) in trillions of m<sup>3</sup>.

Country	gas reserves
China	31,15
Argentina	22,7
Algiers	20
USA	18,8
Canada	16,2
Mexico	15,4
Australia	12,4
South Africa	11
Russia	8
Brazil	6,9
Rest of the world	14
<b>Total</b>	<b>220,7</b>

Source: US Energy Information Administration, June 2013. Own drafting.

In the case of Brazil, however, the reference to a gas revolution addresses firstly the exploitation of pre-salt gas reserves, in that there were no public policies regarding commercial scale exploitation of shale gas. We note that in the PDE 2022 energy plan there was no mention of shale gas. Neither was there any specific legislation when the ANP (National Oil Agency) launched on November 28 2013, the 12th Tender Round. This tender was heavily criticized as it foresees shale gas exploitation, until then non-existent in the country. The main criticism refers to the lack of studies, legislation and prior discussion about the risks of a negative impact due to ground water contamination due to the chemical products used. Simultaneously, in the case of Brazil, there are alternatives underway that demand heavy investments, including gas exploitation in the pre-salt provinces.

## 2.3 Nuclear

Until March of 2011, nuclear energy was going through a worldwide re-evaluation. Being a low-carbon modality, it was being considered as an alternative to fossil fuels<sup>13</sup>. In Brazil, this led, in 2008, to the government announcing plans to begin the construction of new plants, besides concluding that of Angra 3. There were talks about an investment package to generate a 60GW capacity. It is important to recall that of the eleven countries that control the uranium technological cycle only three have significant mineral reserves: USA, Russia and Brazil. The decision to bet on nuclear energy to stand beside hydroelectric plants as the main source of electrical energy had already been challenged, above all due to the lack of sustainable solutions for the high activity radioactive residues. However, a serious accident in Fukushima, in March of 2011, drastically altered the debate on nuclear energy in several regions of the world, with Germany taking the most radical stance abandoning once and for all its projects in this area.

The discussion petered out in Brazil as well. What remained was the Angra 3 conclusion. It is projected to enter into operation in June 2018, with 1405MW in the reserve energy modality (EPE, 2013).

## 2.4 Biofuels

At the beginning of the twenty first century, Brazil was, by far, the leader in the production and utilization of ethanol, which represented 90% of all biofuels. The strong recovery of the sugar and ethanol industry, beginning in 2003, took place within a context of expressive increases in oil prices, and was made possible by the massive introduction of light automobiles using dual fuel engines (flex-fuel) as can be observed in Table 16. This innovation was stimulated by the government, and re-established the consumer's confidence in ethanol as a fuel.

<sup>13</sup> Although nuclear reactors do not emit CO<sub>2</sub>, their emissions throughout their life span have to be considered, and those of the production chain beginning with the extraction of uranium. In this case, emissions are higher than those of other non-fossil sources, such as Wind, solar and biomass (Greenpeace, 2008).



What was also important was the growing concern with the consequences of the GHG for human health in urban centers and with global warming, both relating to the use of gasoline.

**Table 16**

**Light and commercial automobile sales in the domestic market**

	<b>Gasoline</b>	<b>Ethanol</b>	<b>Dual fuel</b>	<b>Total</b>
<b>2005</b>	644.614	49.860	846.710	1.615.585
<b>2006</b>	323.192	1065	1.424.112	1.824.268
<b>2007</b>	234.747	9	2.032.361	2.362.453
<b>2008</b>	223.032	-	2.354.524	2.709.774
<b>2009</b>	221.890	-	2.711.267	3.069.574
<b>2010</b>	660.182	-	2.627.111	3.287.293

Source: ANFAVEA. Annual Directory of the Brazilian Automotive Industry, 2011. Own drafting.

The Energy Research Company (EPE, 2012, p. 14) estimated the circulating fleet of light vehicles in 2011 at 31 million, of which 14.9 million are flex-fuel.

One thing to bear in mind is that if, on the one hand, the flex-fuel engine can be considered a success upon re-conquering the consumer's trust, on the other hand, there is a large room for improvement regarding the efficiency of these cars. Car makers operating in Brazil are multinationals that have based their technological efforts, until a short while ago, on consumption reduction and emissions reduction, regarding only the conventional gasoline engine. The new Brazilian market dynamics has adjusted to this logic, making the most with a minimum of investments. Evaluations by Inmetro regarding the efficiency (in MJ/km) of cars using the flex engine and marketed in 2013, show that when they use ethanol, their efficiency is lower if compared to the use of gasoline<sup>14</sup>. A scholar in the issue, professor Nogueira from the Federal University of Itajubá, also confirms that the dual fuel engine introduced in Brazil is in reality a gasoline

14 Study presented at the Workshop on the efficient use of vehicular ethanol in Brazil, on November 21, 2013, organized by the National Institute for Energy Efficiency (INEE).

engine adapted to use ethanol as well: technologically the efficiency of ethanol should be of 80% in relation to gasoline, and not 70%, as ends up being the case in the dual engines<sup>15</sup>. The challenge for the government is to stimulate assembly plants to invest in upgrading engine performances (Sousa e Macedo, 2009).

Recognizing the great contribution of ethanol in guaranteeing a cleaner energy matrix does not imply denying the negative social and environmental impacts. These, however, may be mitigated through stringent regulation and supervision. Somehow, campaigns against ethanol contribute to materialize this.

Although voluntary certification standards for sustainability have come into play, it is the public policies that truly make the difference towards ensuring there will be convergence between the economic, social and economic gains and the environmental ones. Through Presidential Decree n° 6.961, from September 17, 2009, the government passed legislation banning the expansion of cultivation and installation of sugar cane plants in the biomes of the Amazon, Pantanal and the High Paraguay Basin through the Agroecological Zoning (ZAE) Act, enforced as of the 2009/2010 harvest. The law also forbids the expansion of sugar cane crops and provides for the gradual abolition of burning as a pre-harvest method by 2017, a decision that will entail increased use of mechanical methods. Furthermore, the decree establishes that no authorizations will be granted for the installation or expansion of crops, when there exists a risk to food security. To further support this regulation, the National Monetary Council set forth ecological standards for financing operations for the sugar and ethanol sector, as it was done to combat deforestation in the legal Amazon.

The Decree states that Brazil has approximately 64 million hectares of land suitable for the expansion of sugar cane cultivation, where 18.03 million hectares are considered as having high productive

15 Presentation at the 14th Energy Meeting at Fiesp, at the "Biofuels" table: which solutions can unlock or unleash the sector", held on August 6, 2013 in São Paulo.



potential, 41.17 million hectares an average potential and 4.28 million hectares low cultivation potential. When this survey was conducted during the 2008/2009 harvest, the area planted with sugar cane in Brazil amounted to 7.8 million hectares. Thus, Brazil does not need to incorporate new areas with native coverage to the production process and can expand the sugar cane cultivation area without affecting the land being used to plant food.

Another initiative by the federal government was the National Commitment to Improve Working Conditions in the Sugar Cane industry, articulated in 2008 and 2009. An agreement was celebrated between workers and businessmen in the sugar energy sector, which aimed at valuing and disseminating best practices in sugar cane plantation and fostering the reinsertion of workers laid off due to the mechanization of harvest.

This is no small challenge, which has as its backdrop the transformation of an industry traditionally dominated by conservative power, operating in a modern sector of the economy. A blatant example is the complete lack of respect for the lands of the Guaranis Kaiowás by the ethanol producers in the Southern region of Mato Grosso do Sul<sup>16</sup>.

### Ethanol Crisis

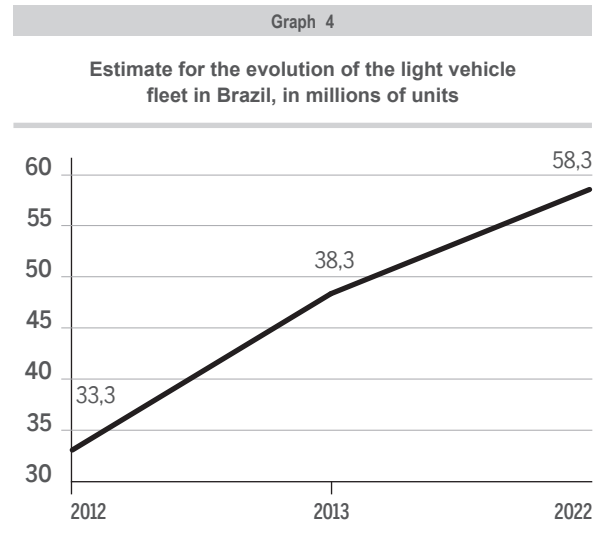
The global crisis of 2008, followed by climate issues, had a huge impact on the highly indebted sugar plants. The lack of investments in renovation and expansion of sugarcane fields, in addition to the climate problems, caused a drop in sugar-cane productivity<sup>17</sup>, with a consequent increases in production costs. To make matters worse, ethanol prices could not be increased to make up for the losses, as the price of gasoline remained relatively stable and bio-fuel prices must not exceed 70% of gasoline prices to remain competitive. A price policy for gasoline came into force, along with a taxation policy, which

16 SeethedocumentaryÀ sombra de um delírio verde (2011), by Cristiano Navarro.

17 Remember that the expansion of sugar cane fields requires a three to five year period.

was totally at odds with any plans to make ethanol the leading fuel. At this point, there was a concentration in this industry, and a denationalization process. According to Bradesco estimates, the foreign share in this industry leaped from 7%, in 2007, to 25%, in 2011<sup>18</sup>. A certain degree of foreign participation can benefit the international promotion of ethanol, but it is necessary to assess the impact on decisions for investments, research and development.

The consolidation of economic growth and better income distribution resulted in the mass consumption standards for a large chunk of the population. Graph 4 shows an estimate from the EPE regarding the future evolution of the fleet, pointing to a scenario, in which the number of light vehicles will increase two-fold. This would imply an increase in energy demands from 50 billion liters of gasoline-equivalent in 2012, to 84 billion of gasoline-equivalent in 2022. Furthermore, the projection shows an impressive increase in the share of light vehicles with flex-fuel engines, from 53% to 76,4%.



Fonte: El Vellant am nis simperumet in cum nonse molupta tqvisi doluptata samus etur

According to EPE's projection in 2011, the increase in fuel consumption would be largely covered by

18 Pinto (2011) calculate an evolution in the participation of foreign capital companies in the sugar and ethanol sector, that began at 7% of the total milling capacity, in 2008, going to 32% in 2011 (Pinto, 2011).



the expansion of ethanol, in that a decrease in the use of gasoline had also been projected. In the 2020 PDE, ethanol consumption was projected to go from 23.715 billion liters in 2011, to 64.6 billion liters in 2020. Very soon, such substantial increase in production proved to be an unrealistic goal. The crisis in the ethanol industry led EPE to review its forecast and, in the 2022 PDE, the projection calls for total consumption of 47.1 billion liters by 2022<sup>19</sup>. Thus, PDE is projecting an increase in use of gasoline from 34 billion liters in 2012 to 43.1 billion liters in 2022. It is worthwhile recalling that in the National Plan on Climate Change (PNMC) from 2008, a growth in demand of 25.6 billion liters is projected for ethanol fuel in 2008, from 38.7 billion, reaching 52.2 billion liters in 2017. Reiterating that the PNMC was launched as an action plan, we should acknowledge a crisis in the ethanol strategy in Brazil, with a negative impact on the trade balance, as the growth in the demand for gasoline was not accompanied by a growth *paripassu* in refinement capacity. There was nevertheless an increase in the imports of oil by-products, at higher prices than those practiced in the domestic market, which means an increase in subsidies for fossil energy.

Between 2010 and 2014, the capital goods industry dedicated to the sugarcane sector registered a drop in sales of about 50% as a consequence of the drop in employment levels. The crisis in this sector also delayed the necessary investments to move forward in the production of second-generation ethanol, also called the pulp ethanol, which would allow for the use of bagasse<sup>20</sup> and sugarcane solid waste. There is a great risk that Brazil, a pioneer in the massive use of ethanol technology, will lag behind in the path to greater energy efficiency and lesser use of arable land, due to the lack of investments, which, in turn, probably result from the lack of a comprehensive strategy. A step towards the right direction was given at the beginning of 2014

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19 The PDE2023 confirms this trend, upon projecting a production of 48 billion liters of ethanol in 2023.

20 In the traditional production process, milling, the bagasse juice is separated and now used to feed the boiler (bioelectricity).

by Finep and the BNDES, when they launched the Joint Action Plan for Technological Innovation in Agriculture in the Sugar Energy Sector, the Agricultural PAISS. As a whole, R\$ 1.48 billion would be available for the 2014-2018 period.

## Bioelectricity

Although the sugar-ethanol industry is basically seen as a producer of biofuel, there is a good potential for the production of bioenergy, based on sugarcane. All the plants in Brazil already produce power for their own consumption, although only 70 of these (40%) have the capacity to transfer the surplus bioelectricity to the power grid. About 200 plants were left on the wayside. Bioelectricity used bagasse as a source, but with the end of the burning in sugar cane fields, it is also possible to use the solid waste, the heat value of which is greater than that of the bagasse.

Difficulties in the hydroelectric sector have already caused a 25% increase in the demand for bioelectricity, between 2012 and 2013, reaching 15 GW. With this, sugarcane bioelectricity became the third source of energy generation in the Brazilian energy matrix, with 7% of the installed capacity. EPE projects (2013) that biomass electricity installed capacity will reach 22 GW by 2022. Hence, we need to create the conditions for long-term investments to become a reality. The crisis in the industry has not only damaged ethanol's production expansion but also caused a drop in productivity, a delay in the technological progress towards the production of second-generation ethanol, and had an adverse effect on the expansion of bioelectricity capacity.

## 2.5 Biodiesel

Biodiesel, or vegetable diesel, is the result of oil extracted for energy purposes. Back in 1982, Brazil began the first tests to evaluate the viability of using biodiesel (mixture of vegetable oil and ethanol). Although the results were positive for biodiesel, the steep cost of the product at the time precluded its commercial use. Notwithstanding this, with the rise in diesel oil prices and that of other oil by-products, biodiesel became an alternative. Its production





costs continue to be higher than that of diesel, always keeping in mind that, as for other renewable energy, the negative externalities of fossil diesel do not have a cost allocated to them.

With the establishment of the National Program for Biodiesel Production (PNPB) in 2004, and as of the approval of Law no 11.097, of January 13, 2005, the federal government introduced biodiesel into the national energy matrix. Thus, at present, all of the vehicular diesel oil sold to consumers has biodiesel and is called Diesel B. The regulatory framework authorizing the commercial use of biodiesel in Brazil also provides for a social-inclusion policy involving family farming<sup>21</sup>. Thus, a Social Fuel Stamp was created, providing a tax cut for biodiesel producers who join in the program. Beginning in 2010, biodiesel producers must necessarily buy a minimum of 50% of raw materials from families registered in the program. However, the family farming program could not be easily implemented in the Northeast, for lack of organization among producers and little access to technologies and production inputs.

Gains in emission reductions relating to fossil diesel and greater gains, when increasing the mixture to 7%, 10% and 20% appear in Table 17.

**Table 17**

**gCO2 emissions and/MJ of the different diesel mixtures of diesel with biodiesel**

Brazilian fossil Diesel without mixture	European Diesel	B5	B7	B10	B20
85.2	83.8	82.1	80.8	79	72.8

Source: Consultoria Delta CO2, CENA/USP

The B5 made Brazil the second largest world producer, second only to the USA and ahead of Germany. Table 18 shows the rapid growth of biodiesel production, and the quick rise in fossil diesel imports to supply domestic consumption.

21 It has been estimated that in 2013 about 100 thousand families were involved in biodiesel production.

**Table 18**

**gCO2 emissions and/MJ of the different diesel mixtures of diesel with biodiesel**

	Diesel B sale	Biodiesel production	Share of fossil diesel imports in total sales
2005	39,2 billion	736 million	6%
2007	41,6 billion	404.000 million	12%
2008	44,8 billion	1,17 billion	13%
2009	44,3 billion	1,6 billion	8%
2010	49,3 billion	2,4 billion	19%
2011	52,3 billion	2,7 billion	18%
2012	55,9 billion	2,7 billion	14%
2013	58,5 billion	2,9 billion	18%

Source: ANP/Abiove

The lack of a clear strategy regarding the biodiesel pace of expansion generated a contradictory situation. On the one hand, we had idle capacity of 55% to 60% (seven billion liters in 2013), and on the other, there was an expressive hike in diesel imports, domestic consumption increasing from 6%, in 2005, to 24% in 2013. It is also important to remember that the oil by-products price-freeze generated costs, due to the difference between the import prices and the diesel prices given by refineries.

## 2.6 Employment in the bioenergy sector

There was a great increase in employment for the sugar-ethanol sector, beginning in 2002, as we see in Table 19. The number of jobs went from 353 thousand to approximately 635 thousand, between 2002 and 2011, i.e. an 80% increase.

At the same time, a drop in the workers involved in sugarcane cutting was recorded and, in contrast, an

**Table 19**

**Direct employment increase in the sugar-ethanol sector between 2002 and 2011**

2002	2007	2011
353 thousand	572 thousand	635 thousand

Source: EPE/PDE (2013)



increase in the number of workers employed in the ethanol industry. There is still a significant part of temporary and clandestine harvest workers not included in this data. The Merkestrat Study, disclosed in May of 2014, calculated 613.235 direct jobs in the sugar-energy sector referring to the year 2013, corresponding to 1.3% of total formal jobs in Brazil. Considering seasonal jobs at harvest peak time, this number reaches almost 1 million (988.236).

Table 20 shows the number of direct and indirect jobs in the biodiesel sector in 2012.

Direct employment	Indirect employment	Total
13.628	68.140	81.768

Source: EPE/PDE (2013)

### 3 New renewable energies

Brazil became a benchmark in terms of traditional renewable energies, with first-generation ethanol and large hydroelectric plants. The term new renewable energies was coined to distinguish this form of generating power from the two traditional renewable sources of energy: the large hydroelectric plants and first-generation biofuels, as the latter does not pose significant potential for expansion under desirable social and environmental conditions. Among the new renewable energies, we have wind (wind power), the sun (solar energy), the sea, geothermal energy (the heat present inside the Earth), sewers, garbage and animal waste, among other matters. Advanced bioenergy, a.k.a second-generation bioenergy could also be included in this group. It is about the potential identified for sustainable energy, but one that is far from being exploited, in that it demands heavy investments and technological capacity for its exploitation, i.e., one that needs well-defined national policies.

#### 3.1 Wind energy

The great surprise at the beginning of 2010 was the take-off of Wind energy. Wind energy got to

the point of dominating auctions in 2013, with contracts amounting to 4.7 GW, implying R\$ 21.2 billion in investments. In 2012, Brazil underwent a silent revolution by increasing its installed capacity from 1.43 GW (2011) to 2.56 GW in 2012, ending up with 40 new farms and reaching a total number of 108 --which was increased to 115 at the end of 2013. Wind energy production capacity should increase two-fold in the next five years, to reach 14 thousand MW installed by 2018 (EPE, 2013).

There has actually been a change in paradigm: Wind energy stopped being a marginal source and took on an outstanding role as one of the complementary sources to hydro energy (side by side with gas, coal and oil and nuclear energy). There used to be a distrust on this energy source due to the fact that wind energy was (as is the case of hydro energy) unforeseeable and intermittent. Two facts made such perception relative: 1) by coincidence, the temporal variation of the wind is the mirror of the hydroelectric one, that is: in thesis, when it rains little in the regions in which the main hydroelectric plants are concentrated, there is much wind in the main wind farms. 2) technology develops rapidly, which made it possible to increase the use of the installed capacity. Therefore, everything points to having the share of wind in the energy matrix increase from 0.8% in 2011 to 4.4% in 2014 and to 7% in 2020. The generation areas are concentrated in the Northeast: the coast of Ceará, Rio Grande do Norte and southeast of Bahia; and in the south: on the coast of Rio Grande do Sul.

Back in 2001, the Research Center for Electrical Energy (Cepel) carried out a survey on Brazil's potential, considering the use of what were, at that time, state-of-the-art turbines, with 50-meter towers. An installable amount of 143GW was reached, of which half derived from the Northeast. What was not considered was the potential of winds in the continental platform of the vast Brazilian coast<sup>22</sup>. Considering the current technology for 100-meter towers, the estimates are that one could more than

<sup>22</sup> These projects present greater specific volume of electrical energy generated by benefitting from the constant wind regimes in the ocean.



double the amount mentioned above<sup>23</sup> and that capacity could fall within the 250 GW and 300GW<sup>24</sup> range, according to the technological stage of development worldwide in 2014. That is to say that Brazil was using only 1% of its potential in 2014.

There is also a job-generation potential. A study in 2012 on this issue shows new potential, accumulated between 2010 and 2020, for 280.179 direct jobs (Simas, 2012), through an input matrix. There is a great challenge regarding endogenous technological capacity. The problem is the non-existence of domestic production for the main components, subcomponents and necessary parts for nationalization. This deficiency is even greater for innovative components, which would have to be imported. Everything depends on the stimuli for innovation. This is an emerging industry that needs strong incentives and R&D to reach economies of scale that will allow it to compete internationally. Once again, note the trade-off between the short-term advantages and the need to guarantee the installation of productive-technological capacity. Acknowledging this problem, the BNDES created a nationalization and progressive industrialization program for 2012-2015. One of the challenges is to guarantee economy of scale in production. Regarding this aspect, it is necessary to stress the potential of other countries in South America and the demand this could generate for wind equipment produced in Brazil. Another area for strategic innovation is the development of smart grids to overcome the technical limitations to expansion, due to the intermittent nature of winds, and the efforts required to avoid disruptions in the grid's voltage (flow management).

### 3.2 Solar energy

Up to 2014, solar energy was in the same place as wind energy before 2011: the sub-utilization was

23 <http://www.brasil.gov.br/infraestrutura/2011/12/energia-Winda-apresenta-altas-taxas-de-crescimento>

24 According to the Chairman of the EPE, Mauricio Tolmasquim, "the Wind potential can reach 300 GW, that is equivalent to the generation of 20 hydroelectric plants in Itaipu" (Fiesp, 2013).

justified by the lack of competitiveness; that is to say, high prices, and no strategy to force changes in this industry. Heavy investments in R&D and short-term stimuli are required to give the sector the possibility of reaching scale and overcoming the necessary learning curves before one can start to see a decrease the costs.

On December 31, 2012, solar energy's share in the total installed capacity of the Brazilian power grid, which amounted to 118.393 MW was negligible: 1 MW (EPE, 2013). Today, Brazil's estimated solar photovoltaic installed capacity is about 20MW, therefore, 95% outside the power grid.

The 2022 PDE states that solar energy in the Brazilian territory would have "high potential for conversion to electrical energy", with the average yearly global radiation between 1.200 and 2.400 kWh/m<sup>2</sup>/year, much higher levels than those seen in Germany and Spain, where these figures vary, respectively between 900-1.250 and 1.200-1.850 kWh/m<sup>2</sup>/year.

Recently, the market for solar energy capturing and transforming dedicated to social interest received strong incentives, thanks to two initiatives. The first is the installing of solar heating equipment as management tool from the demand, by means of energy efficiency programs from companies in the electrical sector. The second is the introduction of systems such as standard equipment in projects of the social housing program Minha Casa Minha Vida- MCMV (federal government housing program). There is indeed a good growth outlook in the use of solar heating systems, impelled mainly by the MCMV Program with installations in more than two million houses between 2011 and 2014. Another positive example was the decision to use solar energy for the new stadiums built for the 2014 World Cup. Silicon photovoltaic modules were installed in the roofing or metallic covering and/or in the surroundings of the arena, in some case guaranteeing up to 30% of their energy needs.

For the time being, the large majority of the photovoltaic modules in Brazil is manufactured abroad. China stands out, as it has become a leader in the production of photovoltaic modules and produces



most of the sheets or boards imported by Brazil.

A strategy is required to develop the solar energy market in Brazil, to attain scale gains, and thus, make it feasible to reach more significant reductions in production costs. This would allow Brazil to participate at some stage of the high added-value industrial chain in the world context. In mid-2014, the government finally announced plans for the continuous organization of auctions to contract solar energy. The EPE projects 3500 MW in contracts of solar energy between 2014 and 2018.

### Final Considerations

A relatively cleaner energy matrix, a relatively low per capita consumption and Brazil's unprecedented example in drastically reducing GHG emissions might discourage critical thoughts about this issue. In other words, Brazil runs the risk of not encouraging the identification and use of other potential sources that would lead to further advances towards a low-carbon economy.

Both the lack of recognition for the progress achieved and the complacency in view of international figures, make it difficult to prioritize concrete actions, so that Brazil may effectively affirm its leading position in the global struggle towards a low-carbon economy.

With the drop in deforestation, there has been a qualitative change in the structure of the GHG emissions. Energy, which used to be in a background plane, emerges now as one of the most important sectors, side-by-side with agriculture; demanding specific policies and public debates.

In principle, there is no inherent contradiction between the exploration of the pre-salt oil and a commitment towards a low-carbon economy. It all depends on how the riches will be managed and on the strategies for exploitation and production. What does exist is the risk - which must be avoided - of having the pre-salt sully the Brazilian energy matrix.

The debate regarding the need to adapt the expansion strategy for the electrical sector would still

exist, regardless of the climate problems verified during the first months of 2014 because there are limits regarding hydroelectric expansion, due to the social and environmental issues.

Natural gas, albeit a fossil energy source, is superior to other fossil sources because it enables a significant reduction in GHG emissions. The scenario of the natural gas market in Brazil has changed, thanks to the prospects of a large increase in domestic production of gas in the next few years. This allows room to rethink the role of natural gas in the Brazilian energy matrix (as a source for thermal plants, transportation and industry). In this context, the increase in use of natural gas to the detriment of other fossil sources should become part of a strategy on that path towards a low-carbon economy. What must be avoided, however, is to allow more natural gas use to take place to the detriment of the use and investments in renewable sources.

Post-Fukushima (2011), the Brazilian government suspended its plans of betting heavily in nuclear energy, with the exception of Angra 3. This decision, in view of the present-day stage of nuclear technology, and considering the alternatives that Brazil has at hand, is the right decision. By the same token, investments in Angra 3 are important because they allow Brazil to master and keep up with the development of nuclear technology. We must not once and for all discard the idea that this is a technological route that may one day contribute with solutions to the supply of energy.

Acknowledging the great contribution of ethanol towards guaranteeing a cleaner energy matrix does not imply denying its negative social and environmental impacts. These, however, can be minimized through stringent regulation and supervision based on the Agroecological Zoning (ZAE) guidelines for sugar cane, in force since 2009.

The crisis in the ethanol sector delayed the investments required to move ahead towards the second-generation production, also called cellulosic ethanol. A comprehensive policy is required, to inject this industry with new vigor, and reconfirm ethanol's priority in the energy matrix, to create a taxa-



tion policy to support the production of ethanol and provide incentives for the acquisition of capital goods for cogeneration/ bioelectricity. In view of these multiple challenges, it is time to think about specific legislation that would organize this sector, as well as to revisit the taxation framework.

There is great potential to significantly expand the use of biodiesel to the detriment of fossil-origin diesel, leading to environmental gains and dispensing with costly diesel imports. Furthermore, there is a good chance that jobs will be generated and Family Farming strengthened. For Brazil to make the most of the potential regarding biodiesel, an encompassing strategy is required, including everything from investments in raw materials to technology to enhance truck engines, making it possible to use this fuel with a mandate that is greater than the present-day 7%.

The expressive leap forward in the installed capacity for Wind energy in 2012 should be acknowledged. This is when Brazil increased its installed capacity from 1.43GW to 2.56GW. A comparison with other countries with great Wind potential shows an enormous difference in scale: China, with installed capacity of 62.3GW, the USA with 47GW and Germany with 29GW. Brazil's potential has been estimated between 250 and 300GW. That is to say that with the leap in 2012, Brazil has exploited only 1% of its potential.

To guarantee continuity in the expansion of wind energy, it is necessary to have a comprehensive strategy, involving taxation policies and financing conditions to guarantee the installation of a production-technological base. Furthermore, there is the challenge of planning the incorporation of wind potential into the electrical network, considering its specific characteristics. Technological investments should also prepare exploitation of the offshore wind potential. What can be gained, in environmental terms and those of employment generation, is enormous.

The clear under-utilization of the great solar energy potential is clear, justified by the lack of competitiveness in auctions, that is to say, the high price

without a strategy to force changes in this sector, with stimuli to launch the industry and reach economies of scale and heavy investments in research and development. Specific auctions could help stimulate the solar energy sector in Brazil, offering security for photovoltaic module plants to settle in the country, thus strengthening the production chain with the generation of jobs and an endogenous capacity.

The transportation sector has become one of the most responsible for the GHG emissions in Brazil, following the global emissions standards. Therefore, it also offers the greatest opportunities for mitigation measures. The challenge is to frontally tackle this inheritance of concentrating cargo transportation on land transportation, a reality that has been consolidated since 1950. There is an under-utilization of waterway transportation and the potential to transport cargo through cabotage.

Brazil has bet on voluntary mechanisms to stimulate automobile assemblers to invest more in efficiency and in less pollution, while the European experience has shown the need to make these goals mandatory. Technical standards and investment in technology can mitigate the GHG emissions and would be crucial, as there is no reason for Brazil not to follow the most advanced standards worldwide. The increase of efficiency of the flex-fuel engine should be included among the priorities.

Another problem that has to be faced head on is that the market price does not reflect the gains in positive externalities. This creates a risk of having over-investments in fossil fuels and under-investments in renewable energies. GHG should be deemed a negative externality. Without imposing a cost on the GHG emissions, any initiative for mitigation will be short lived. Taxation on the use of carbon could play this role.

It is essential for Brazil to dominate the production chain of renewable sources of energy: solar and wind, second-generation of biofuels and the use of international partnerships to create an endogenous capacity, very similar to what Petrobras did and is doing in the field of exploitation and production of



oil in deep and ultra-deep waters. The risk of a new technological dependence must be avoided.

## Bibliographic References

Abraça. A lei solar em São Paulo. São Paulo, 2009.

Assunção, J; Gandour, C.C.; Rocha, R. A queda do desmatamento na Amazônia brasileira: preços ou políticas? Climate Policy Initiative. PUC-RJ, janeiro 2012.

Bermann, Célio. Energia no Brasil: para que? Para quem? São Paulo: Editora Livraria da Física, 2002.

Calou, Silvia Maria. Energia e Mudanças Climáticas: otimismo e ameaças no fronte brasileiro. In: Motta, Ronaldo Seroa &ea (Org). Mudança do Clima no Brasil, IPEA, 2011.

Cepel. Atlas do potencial eólico brasileiro. Brasília, 2001

Confederação Nacional da Indústria (CNI). Relatório Infraestrutura, novembro 2013.

\_\_\_\_\_. Energia e competitividade na era do baixo carbono. SPR/CNI, julho 2010

Embrapa. Mitigação das Emissões de Gases de Efeito Estufa pelo Uso do Etanol de Cana-de-Açúcar produzido no Brasil. Circular Técnica nº 27. Serópedica. RJ, Brasil, 2009.

EPE. Análise da inserção da geração solar na matriz elétrica brasileira. Rio de Janeiro, maio de 2012.

Fiesp. Estratégia de potencial socioeconômico pleno para o Brasil. São Paulo, 2013.

Governo Federal. Plano Setorial de Transportes e Mobilidade Urbana. Brasília, 2012.

\_\_\_\_\_. Plano Nacional sobre Mudança do Clima. Brasília, dezembro 2008.

Greenpeace/ Centro de Estudos Integrados sobre meio ambiente e mudanças climáticas. Eficiência Energética e Emissões de Gases de Efeito Estufa. Abril 2014.

\_\_\_\_\_. Horizonte Renovável. São Paulo, 2013.

\_\_\_\_\_. (R)evolução energética – a caminho do desenvolvimento limpo. Cenário brasileiro 2013.

\_\_\_\_\_. Greenpeace. Cortina de fumaça. As emissões de gases estufa e outros impactos da energia nuclear. São Paulo, 2008.

IEA. Internacional Energy Outlook 2013. Paris, 2013.

\_\_\_\_\_. Redrawing the Energy-Climate Map. WEO Special Report. Paris, 2013.

IPAM. Pegada de carbono dos gastos tributários. Outubro 2013.

IRENA. Renewable Energy and Jobs. Annual Review. Abu Dhabi, 2014.

Melo, Elbia. Fonte eólica de energia: aspectos de inserção, tecnologia e competitividade. Estudos Avançados 27 (77), 2013.

MCTI. Estimativas anuais de emissões de gases de efeito estufa no Brasil. Brasília, 2013.

\_\_\_\_\_. Segundo Inventário Brasileiro das emissões e remoções antrópicas de gases de efeito estufa. Brasília, 2010<sup>a</sup>.

Ministério das Cidades/ Ministério dos Transportes. Plano Setorial de Transporte e de Mobilidade urbana para mitigação e adaptação à mudança do clima (PSTM). Brasília, 2013.

Miranda, Mariana M. Fator de emissão de gases de efeito estufa da geração de energia elétrica no Brasil. Dissertação. USP/São Carlos, 2012.

MMA. Primeiro inventário nacional de emissões



atmosféricas por veículos automotores rodoviários. Brasília, 2011.

MME/EPE. Plano Decenal de Expansão de Energia 2022. Brasília, 2013.

\_\_\_\_\_. Balanço Energético Nacional. Rio de Janeiro, 2013.

MME. Balanço Energético Nacional 2014.

\_\_\_\_\_. Relatório de Atividades do Comitê Gestor de Indicadores e Níveis de Eficiência Energética (CGIEE) 2009-2010. Brasília, 2011.

\_\_\_\_\_. Plano Nacional de Eficiência Energética: premissas e diretrizes básicas. Brasília, 2011.

\_\_\_\_\_. Relatório de Atividades do Comitê Gestor de Indicadores e Níveis de Eficiência Energética (CGIEE) 2002-2008. Brasília, 2009.

MT. Plano Nacional de Logística e Transporte. Reavaliação de estimativas e metas. Relatório Final. Brasília, setembro 2012.

Nogueira, Luiz Augusto Horta. Promovendo a eficiência energética nos automóveis brasileiros. Relatório para o CONPET. Junho de 2005.

Petrobras. Plano Estratégico 2030. Rio de Janeiro, 2014.

Simas, M; Pacca, Sergio. Energia Eólica, geração de emprego e desenvolvimento sustentável. Estudos Avançados, Vol 27/ no 77, 2013

Simas, M. Energia Eólica e o desenvolvimento sustentável no Brasil: estimativa da geração de empregos por meio de uma matriz de insumo produto ampliada, 2012. FEA/USP, Dissertação de mestrado.

Sousa, E. L; Macedo, I.C. Etanol e biodiversidade: a cana-de-açúcar no futuro da matriz energética. São Paulo: Única, 2009.

Tolmasquim, Mauricio T; Guerreiro, Amilcar E;

Gorini, Ricardo. Matriz Energética Brasileira. Novos Estudos 79, novembro 2007.

World Resource Institute (WRI). Climate Analysis Indicators. Washington: WRI, 2010.



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