Brazilian ethanol as an alternative to vehicular electrification to achieve COP21 targets

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ABSTRACT

Brazil is one of the largest producers of biofuels in the world and the only country to have a vehicle fleet with more than 60% of flex fuel cars of the total number of vehicles, which is possible to use gasoline and / or ethanol [1]. This places Brazil in a leading position in the initiatives to reduce greenhouse gases, to be corroborated by the carbon intensity of the Brazilian vehicular matrix of vehicles that is already low (74.25 g CO2eq / MJ - well to wheel) when compared to most other countries. And this value can reach even lower levels of about 20.79 g CO2eq / MJ if a use of hydrous ethanol (94%) is considered [2]. However, today there is a worldwide trend towards vehicular electrification from the use of lithium and cobalt batteries and external power generation, which is often mistakenly adopted without assessing the context and the natural vocation of each country. Therefore, in order to support the development of future technologies of the automotive and energy industry, the present study aims to present and discuss the motivations of Brazil for the maintenance and expansion of policies to encourage biofuels versus the alternatives of vehicular electrification adopted in the countries developed to mitigate the effects of greenhouse gases (GHG).

Key-words: Ethanol. Biofuels. Electrification. Greenhouse Gases (GHG).

1. INTRODUCTION

The effects of greenhouse gases are increasingly evident and have impacted the climate as never before. Due mainly to industrial and population growth, the concentration of carbon dioxide (CO2) gas has grown exponentially in recent years and today is close to 416 ppm, a value never reported [3]. The temperature of the earth has risen 1.2ºC in the last 100 years, that is, since the beginning of the industrial revolution, which can show the responsibility of the gases generated by the productive sectors [4].

According to the IPCC report of 2018 (Intergovernmental Panel on Climate Change), with the current trend of GHG emissions, the temperature of the earth is expected to increase by up to 4.8 ° C. As a result, sea level will be affected and is expected to rise by as much as 82 centimeters by 2100. Rains are projected to increase by about 20 percent and global warming will be different in every part of the world. As an example, continents should feel more of these effects than the oceans and the northern hemisphere, which tends to be more affected than the southern hemisphere [5].

Since 1994, the United Nations has debated the global climate agenda and sought to negotiate rules and policies in the so-called Conference of the Parties (COP). Significant progress has been made in these negotiations, such as the Kyoto Protocol (COP3 - 1997), which refers to the reduction of 5% of GHG by 2012 with base year 1990. However, many impasses have been observed ever since, and dialogue between participants has always been involved interests.

The last breakthrough was achieved at COP21 (Paris - 2015) where an agreement was reached by acclamation of almost all participating countries on measures to reduce global warming. Since then, upcoming conferences have been keen on details so that this agreement has clear goals and that each country can measure whether its commitments are being met.

As a global target, countries should primarily reduce GHG emissions to limit global warming by at most 1.5 ° C by 2100 [6].

2. THE PROFILE OF WORLD AND BRAZIL EMISSIONS

As seen in Chart 1, the economy sectors that emit the most GHG in Brazil do not apply to the sectors that emit most of the world. In this projection of GHG emissions for the year 2030, corresponding to the great world emitters of energy and terrestrial transports, corresponding to 43% of the total. In the Brazilian case, the main emitters of GHG are linked to deforestation, land use change, polluting techniques of agriculture and agriculture, and are usually associated with the use of nitrogen fertilizers, with 72% of the total. Still in Brazil we see that the land transport sector is the third largest emitter with 10% of emissions, but much smaller than the sum of the first two places. When we compare the share of emissions from the world's terrestrial transport with that of Brazil, we see that the country emits much less in percentage numbers [4].

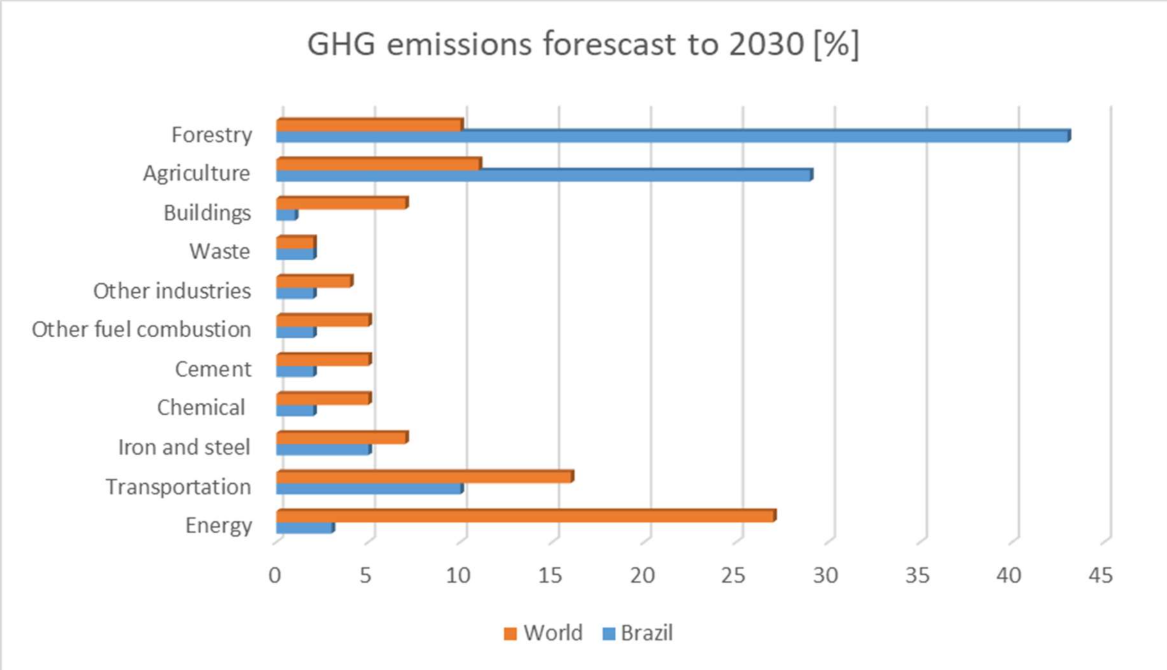

Chart 1: Comparison between the profiles of GHG emissions from Brazil and the world in 2030 [Source: Caminhos para uma economia de baixa emissão de carbono no Brasil - McKinsey&Company 2009].

In Chart 2, it can be observed that between 1990 and 2016, GHG emissions increased from 1.72 Giga tons of carbon dioxide equivalent (GtCO2e) to 2.27 GtCO2e, an increase of 32%, where 51% came from deforestation Amazon and the Cerrado. Note that the world emissions in this period grew at an almost constant rate, while Brazil varies its emissions due to the waves of growth and retraction of the economy. Between 2015 and 2016, it is possible to notice a 9% increase in emissions due to the increase of the herd of cattle because the recession caused a smaller slaughter, together with an increase of the changes of the land use [5].

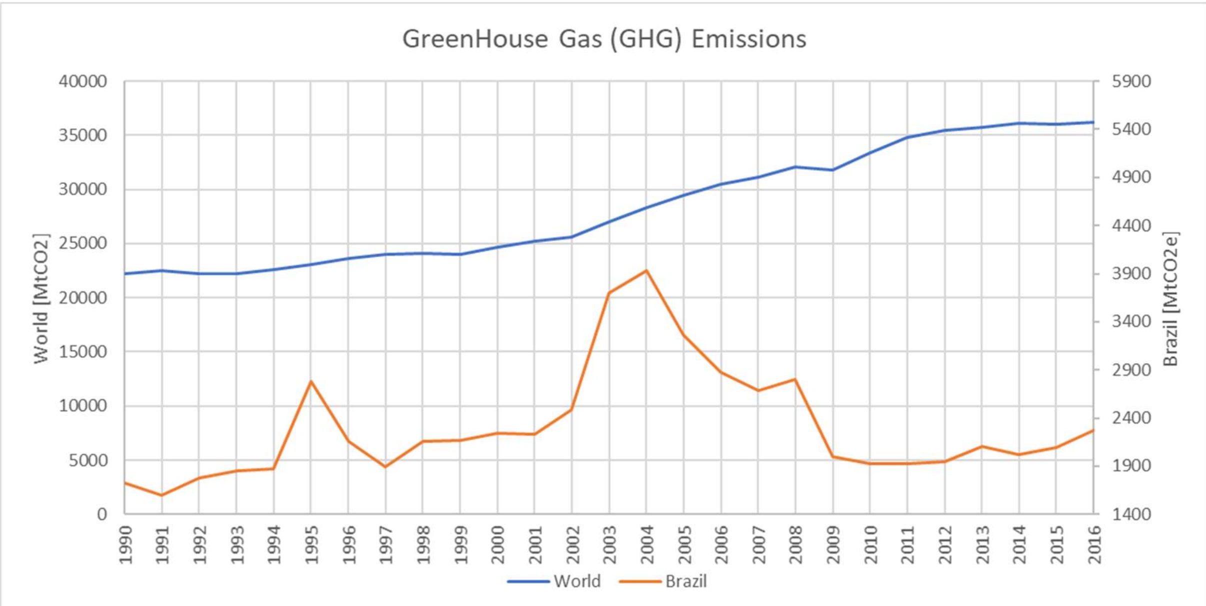

Chart 2: GHG emissions in Brazil and the world between 1990 and 2016
[Source: SEEG - Emissões de GEE no Brasil 2018 e ourworldindata.org]

The activities of Agriculture and Land Use Change (LUC) are the main sources of greenhouse gases in Brazil, accounting for about 70% of emissions as shown in Chart 3. Nearly two-thirds come from the conversion of forest into pasture and agricultural areas, and the other part comes from direct emissions from these activities, such as methane (CH_4), emitted by enteric fermentation in livestock and handle of animal excrements, and nitrous oxide (N_2O), because of the use of nitrogen fertilizers. Land use change (LUC) corresponds to emissions due to changes in vegetation cover (deforestation or reforestation) and changes in land use, including crop variations and their applications of chemical implements for soil correction [5] [7].

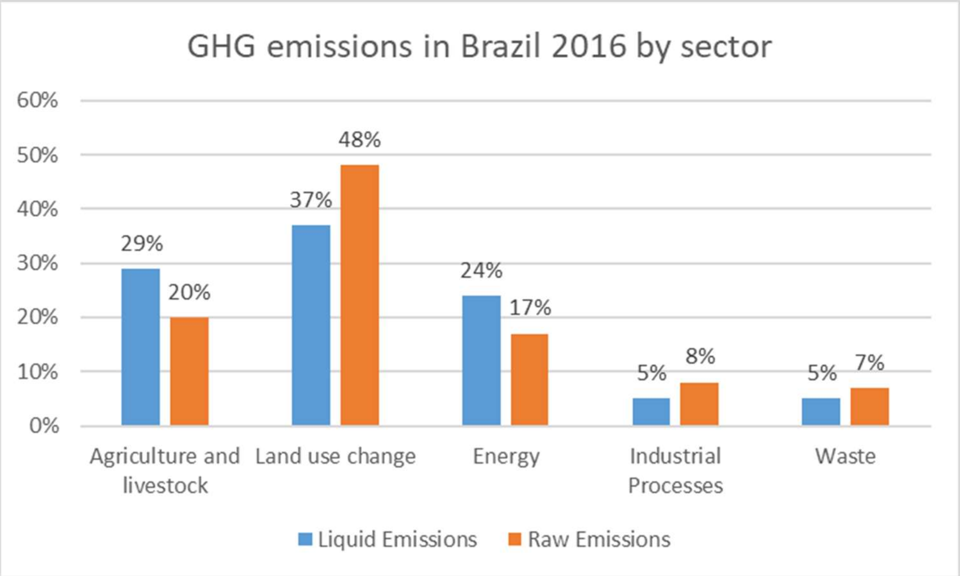

Chart 3: GHG emissions in Brazil by sector in 2016
[Source: SEEG - Emissões de GEE no Brasil 2018]

In this way it is clear which are the major GHG actors in each scenario and, it can be inferred that the actions that Brazil must adopt differ from those that other countries will follow in order to reduce GHG in their modalities, since the profiles of the polluters are different. However, this does not mean that good practices should not be adopted in all sectors for all kinds of contributions.

3. COMPARATIVE OF RENEWABLE ENERGY SOURCES OF BRAZIL AND THE WORLD

Brazil is one of the countries with the highest percentage of renewable energy in the world [8]. By 2017, 43.2% of all its energy came from "green" sources. Within this segment, ethanol and sugarcane bagasse generated 40.3% of this amount, and secondly, electricity from 27.5% of the water source. Compared with the world average, the country has a great advantage, since the percentage around the world was only 13.8% in 2017. In the member countries of the Organization for Economic Cooperation and Development (OECD) this percentage is even lower, of only 10%. When energy is not from renewable sources, they are extracted from sources with high CO_2 emissions, such as petroleum, natural gas or mineral coal [9].

In the context of the decarbonization of energy sources, these countries have invested heavily in renewable sources such as wind and solar, but the horizon to reach the percentage numbers like Brazil is far. In 2017, the entire Brazilian energy sector issued 1.47 tons of carbon dioxide per ton of oil equivalent (tCO_2 / tep) compared to 2.34 tCO_2 / tep of the world average, almost 40% less [9]. One way to reduce CO_2 emissions may be to increase the energy efficiency of energy-using technologies from these sources. In that sense, many countries are struggling in the transport sector through cars. As it is difficult to find alternatives to quickly replace the current energy matrix for a renewable energy matrix for transport. Vehicles with technology through the concepts of engine downsizing is an alternative used to reduce energy consumption.

Today it is a consensus that electric vehicles have a much higher energy efficiency than combustion vehicles. On average, a vehicle with an internal combustion engine requires 1.60 to 1.80 MJ to cover one kilometer. Already an electric vehicle uses only half of this energy (about 0.75-0.80) to travel the same distance.

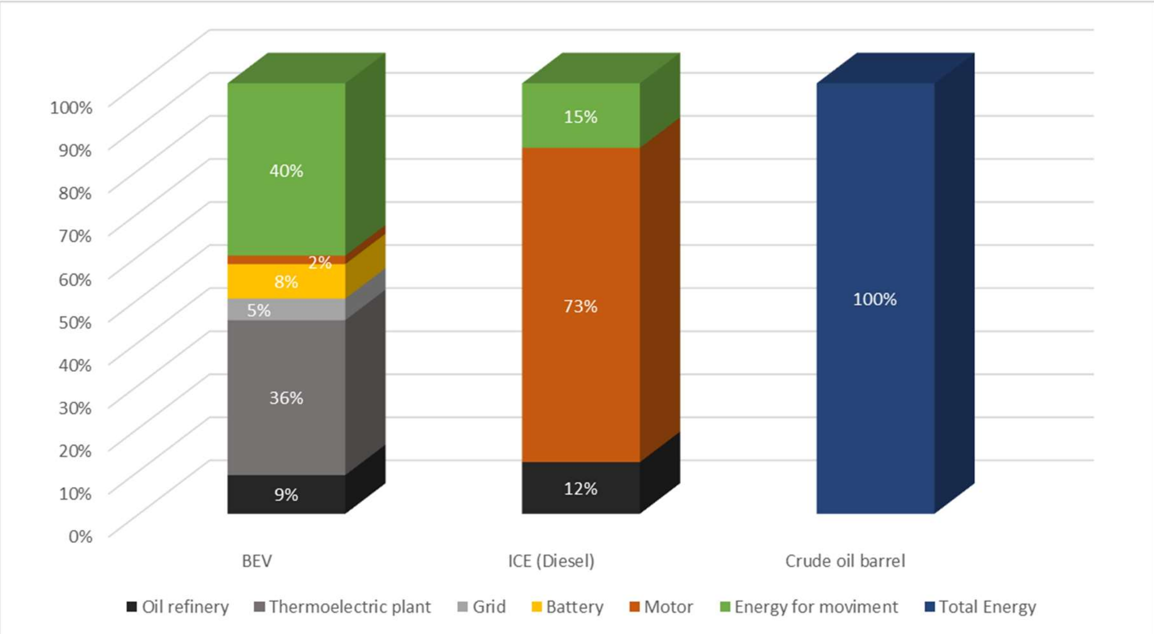

Chart 4: Energy efficiency of an internal combustion vehicle and an electric vehicle [Fonte: data adapted from Itaipu Binacional]

To assert that electric vehicles do not emit CO2 can be considered true in the transformation of electric energy into energy of movement by the electric motor, that is, from outlet to the wheel. But the generation of this electric power can be from various sources if considered from the well to the wheel. Non-renewable CO2-emitting sources are used for electricity generation in many countries and the actual CO2 emission of the electric vehicle to charge its batteries then depends on the energy matrix from which it occurs.

The second law of thermodynamics shows us that all the transformation of energy passes from a nobler source to a less noble one, the noblest one being the one that can generate more work. Although the first law of thermodynamics says that the amount of energy is preserved in transformation, the quality of energy is always degraded and involves yields of less than 100%, a part of the available energy being transformed into a more dispersed and less useful form in general in heat transferred to the environment [10].

4. COMMITMENTS OF BRAZIL AT COP21 AND THE CONTRIBUTION OF THE TRANSPORT SECTOR

In the Paris agreement (COP21), each country should indicate its own GHG reduction targets, and the commitment to achieve them according to the dates indicated. Brazil has defined its goals and recorded in its Nationally Determined Contribution (iNDC) document [6].

Brazil has committed itself to reducing its greenhouse gas emissions by 37% by 2025 compared to 2005 (limiting them to 1.3 billion tons of carbon dioxide equivalent), and 43% in 2030 also in relation to 2005. According to the Ministry of Science, Technology, Innovations and Communications (MCTIC), Brazil's growth rate is 0.6% per annum by 2020 and 2.3% by 2025, and the agreement can be met by 2025 investment of US$ 1.7 billion. Already by 2030, the country must grow again, which increases this cost to US$ 11.1 billion [11].

A specific goal for the energy sector assumed by Brazil is the achievement of 45% of renewable energies in the energy matrix in 2030. By 2016 it already equaled 42% [6]. It also made a commitment to increase sustainable bioenergy to 18% by 2030. In the ethanol sector this amounts to reaching 50 billion liters in 2030, and in 2018 produced 30 billion liters, which means an investment of R$ 161 billion in the sugar-energy sector [9].

Regarding the energy sector, transport is the main responsible for the generation of greenhouse gases. As of 2009 there is a marked increase in emissions in the transportation sector due to the greater use of gasoline due to the policy of low prices of this fuel adopted by the federal government. From 2013 onwards, this trend will begin to reverse thanks to the recovery of the ethanol industry. There is a direct relationship between the sale of ethanol and the reduction of CO2 emissions. This shows the need to maintain policies that encourage the use of this renewable energy in this segment [5].

5. THE IMPACT OF BRAZILIAN ETHANOL

Brazil is the world's largest producer of ethanol from sugarcane in the world and in the 2018/2019 crop hit a record production and consumption, where it reached more than 33 million liters. The consumption of anhydrous ethanol in Brazil, which is mixed in proportion to gasoline A (pure) to form gasoline C (27% of ethanol required by law in the total blend [12]), reached more than 10 million liters. The consumption of hydrated ethanol, which is sold for supply of light vehicles in Brazil (with an alcoholic graduation between 95.1% and 96% [13]), reached more than 19 million liters [14]. Brazil has 410 sugarcane mills, most of it in the state of São Paulo, the largest producer [15]. In 2017, it registered 765 thousand jobs with a formal contract with one of the highest salary averages in the sector [16].

According to the International Energy Agency (IEA), Brazil's ethanol achieves 89% reduction of CO2 gases, as it is produced from sugarcane. This number drops to 46% if it were produced from beet, as is most of the ethanol produced in Europe, and still to 31% for US ethanol, which is produced from corn. This is due to the fact that agricultural crops are sources of CO2 capture, which is used by plants in the process of growing and producing energy through photosynthesis in the presence of sunlight [16].

When analyzed the ethanol production chain we have the following steps [16]:

The sugarcane plantation and harvest phase require agricultural inputs and land treatment, which emit CO2 along with machinery, which uses diesel fuel as fuel, totaling 2,961 kg of CO2 per 1000 liters of ethanol.

In the growth phase of the plant, this same volume of ethanol absorbs 7,650 kg of CO2.

In the processing stage, fermentation and distillation transform energy into its process and emit 3,604 kg of CO2. The bagasse still generates electricity, and at this stage 225Kg of CO2 is avoided for this same volume of production. Transportation of production is also accounted for by using non-renewable fuel in its trucks, which generates 50Kg of CO2, and the use of this volume of ethanol in the final consumer's vehicles generates 1,520Kg of CO2.

Therefore, adding the CO2 emissions of this whole process and subtracting what has been absorbed in the growth of sugarcane and avoided in the generation of its own energy, it reaches a total of 260Kg of CO2 for every 1000 liters of ethanol produced and consumed. The equivalent use of gasoline A generates 2,280 kg of CO2, which results in a reduction factor of 89% when using cane ethanol.

The electricity generated in the ethanol production plants is produced by sugarcane bagasse, and the production surplus is sold to the electric power distributors. Cane harvesting and ethanol production take place during the drought period of the southeast region in the middle of the year, precisely when the reservoirs of the hydroelectric power plants in that region are lower. In the Northeast, the drought phase, consecutively the cane harvest, takes place at the beginning of the year. The installed capacity of energy generation using sugarcane bagasse is 11.4 GW, corresponding to 6.6% of the total in Brazil [17].

Studies show that sugarcane does not compete with food production in Brazil. In the 2018 report of Companhia Nacional de Abastecimento (CONAB), sugarcane occupied 8,613 thousand hectares, about 1% of the 851 million hectares of Brazilian territory, where 7% is occupied by plantations. For comparison purposes, 23% of the national territory is occupied by pastures. Taking into account production and consumption numbers, Brazil would need 2% of its arable land to move the entire Brazilian fleet of light vehicles exclusively with ethanol [16].

In the next decade there is the prospect of doubling production using the same area currently occupied by sugarcane using second-generation ethanol. In this case, sugarcane bagasse is also used as raw material to produce ethanol. In traditional production, the cane is pressed, the juice is extracted, fermented and distilled, generating the ethanol. With the commercial sugar cane species, traditional production is around 92 tons per hectare, which generate more than 6500 liters of ethanol [18].

Using the second-generation technique bagasse and straw from sugarcane are treated chemically or physically so that the lignocellulosic material, the main structural component of the matrix, is reduced in fermentable sugars (glucose and xylose). The fermentation of sugars allows an increase of 66% in the total ethanol produced per hectare [18].

Another advance is the use of new cane varieties, known as energy-cane, which has a higher percentage of fibers and higher productivity per hectare. As a comparison, production per hectare is 180 tons before 92, ethanol production per cane juice is 7100 liters, and that of cellulosic ethanol is 13177 liters, an increase of 9% and 204% respectively in relation to the variety commercial sugarcane [18] (Table 1).

The total ethanol production using energy-cane for traditional ethanol and second generation per hectare is 20,277 liters. An increase of 87% compared to the same process using commercial sugarcane, and an increase of 211% compared to traditional production using only juice from the commercial variety sugarcane press in the distillation process. It is expected that in the next years the production can reach 24800 liters per hectare with the evolution of the machinery for second generation ethanol with the use of energy-cane [18].

Table 1: Comparison of production between technologies for ethanol
[Source: updated date from Santos et al. 2016]

		Ethanol 1st generation		Ethanol 2nd Genaration		Total	
	Production	*Sugar Extraction*	*Ethanol*	*Bagasse*	*Ethanol*	*Ethanol*	*Electric energy*
Sugar Cane	92 ton/ha	11.2 ton/ha	6525 L/ha	39 ton/ha	4338 L/ha	**10863 L/ha**	25.8 MWh/ha
Energy Cane	180 ton/ha	12.2 ton/ha	7100 L/ha	110 ton/ha	13177 L/ha	**20277 L/ha**	67.6 MWh/ha

According to the study published by the Center for Strategic Management and Study (CGEE) [19] in 2025 the world will use 1.7 trillion liters of gasoline A. The FlexFuel engines of Brazil have a factor of 70% efficiency for the use of ethanol compared to the performance of gasoline A, that means a vehicle that walks 100 miles with gasoline will travel 70 km using the same amount of ethanol. Applying this factor to the predicted use of gasoline in 2025, the world would need 2.4 trillion liters of ethanol if it would only use ethanol as fuel in gasoline-powered vehicles. If we use the forecast of 24800 liters of ethanol production per hectare for the volume of ethanol needed for the world's gasoline-powered fleet, we have reached an amount of about 100 million hectares needed for planting.

Brazil has a territory of 851 million hectares, so that 30% is destined for pastures (23% or 198 million hectares) and plantations (7% or 60 million hectares), as we can see in Figure 5. Of the total of hectares for pasture, about 70 million hectares are degraded and underutilized pastures. That is, using these lands it is possible to produce more than half the amount of ethanol needed to supply the world in 2025 without competing with food production and without degrading and deforesting biomes [19].

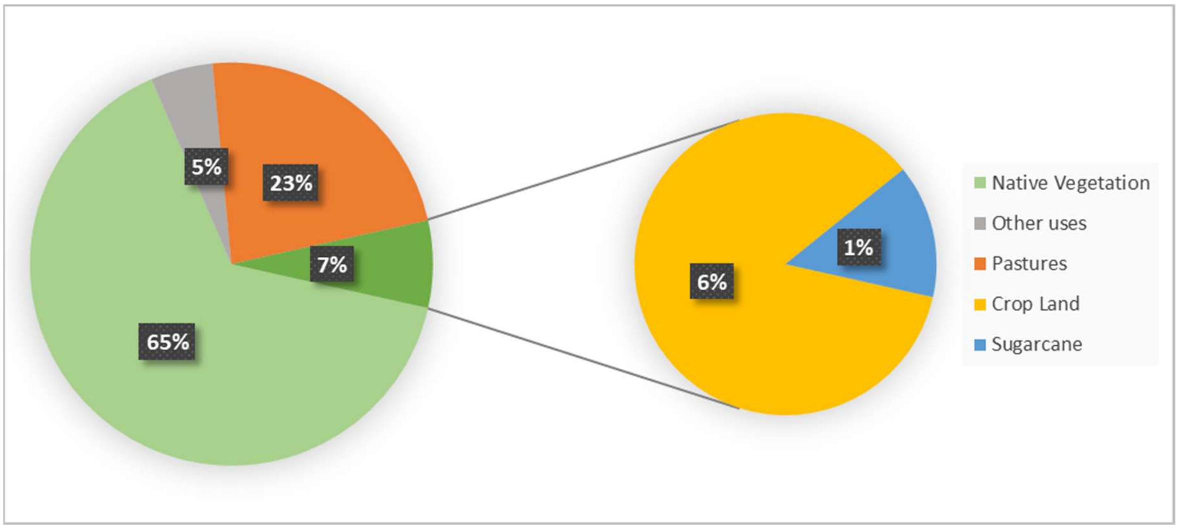

Chart 5: Distribution of crops in Brazilian land
[Source: ICONE, ESALQ e IBGE]

6. THE SALES OF ELECTRIC VEHICLES (EV) IN THE WORLD AND ITS INCENTIVES

The sale of new EV has grown 64% in 2018 over the previous year and has maintained this strong growth in recent years. China has led this movement, followed by the US. The countries of Europe and Japan have a strong call for the electrification of transport to reduce the emission of gaseous pollutants. Sales of light-duty electric vehicles hit record highs each year and reached a record total of 5.4 million units by the end of 2018 [20].

Despite the strong growth of electric vehicles in the world, they still represent a low percentage in the fleet of light vehicles of their respective countries. According to the Global EV Outlook, IEA, 2016, for the transport sector there is a need to reach 140 million EV by 2030, which corresponds to 10% of the world fleet of light passenger vehicles [21]. By 2017, China had less than 1% of its electrified fleet and the United States less than 0.5%, with Japan, England, France and Canada close to that percentage.

Many incentives have been offered to EV owners, such as discount on the final purchase value, reduction or exemption from property taxes, areas restricted to the use of low carbon vehicles, parking places, etc. Each country has its specific package of advantages to attract new EV buyers and maintain existing fleet. China offers incentives of US$6,000 to US$10,000 and acquisition tax exemption. Japan offers incentives of up to US$7,800.00, France up to US$7,100.00 for battery electric vehicle (BEV) and the UK up to US$6,300.00 for BEV [21].

In the United States, each state offers a benefit package for low-carbon cars. As an example we have California, which historically is one of the states that most lead innovations and laws for the environment and safety in transportation [21] [22].

Table 2: Comparison of cost of internal combustion engines vehicles (ICE) and BEV [Source: Vehicle Cost Calculator – U.S. Department of Energy]

Vehicle	Annual Fuel Use	Annual Electricity Use	Annual Fuel /Elec Cost	Annual Operating Cost	Cost Per Mile	Annual Emissions (lbs CO_2)	Regular Price
2018 Kia Soul 4cyl 1.6L Aut Gas	433 gal	0 kWh	$1,247	$3,504	$0.29	10,389	$16,100
2018 Kia Soul Electric EV	0 gal	3,835 kWh	$725	$2,830	$0.24	2,185	$34,945
2017 VW Golf 4cyl 1.8L Aut Gas	401 gal	0 kWh	$1,156	$3,413	$0.29	9,632	$20,995
2017 Volkswagen e-Golf EV	0 gal	3,434 kWh	$649	$2,754	$0.23	1,956	$28,995
2017 Ford Focus 4cyl 2.0L Aut Gas	388 gal	0 kWh	$1,117	$3,375	$0.28	9,31	$16,775
2017 Ford Focus Electric	0 gal	3,803 kWh	$719	$2,824	$0.24	2,167	$29,120

Assuming: 80% highway and 3596 annual mileage. California taxes. Vehicle costs including fuel, tires, maintenance, registration, license, insurance, and loan payment. Five-year loan with a 10% down payment. For more details check https://afdc.energy.gov/calc/

In charts 6, 7 and 8 there is a comparative referring to the life cycle price of equivalent vehicles with internal combustion engine and electric motor.

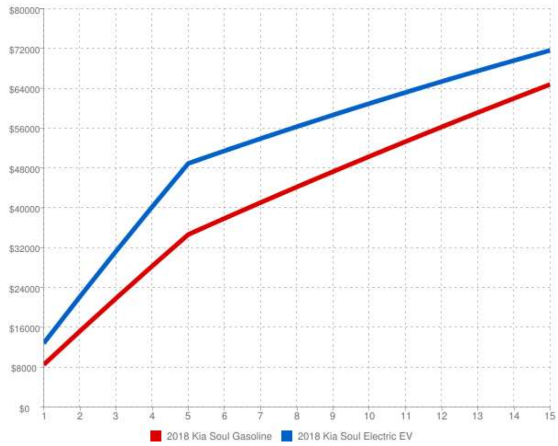

Chart 6: Comparation of “Kia Soul 4cyl 1.6L Aut Gas 2018” in red line with the “Kia Soul Electric EV” in blue line

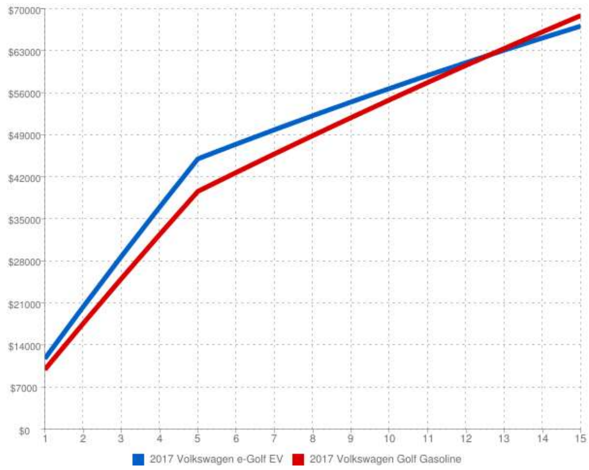

Chart 7: Comparation of “VW Golf 4cyl 1.8L Aut Gas 2017” in red line with the “Volkswagen e-Golf EV 2017” in blue line

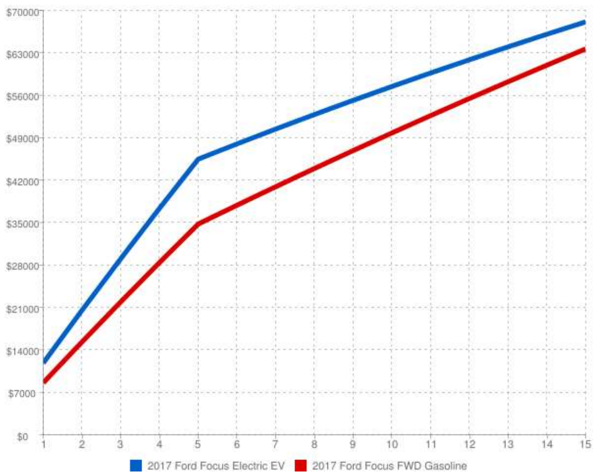

Gráfico 8: Comparation of “Ford Focus 4cyl 2.0L Aut Gas 2017” in red line with the “2017 Ford Focus Electric” in blue line
[Source: Vehicle Cost Calculator – U.S. Department of Energy]

It is noted that the electric vehicle has a high value for acquisition. Countries that need to reduce carbon emissions from the fleet of light vehicles using electrification are offering high incentives to purchase these models, but they do not always become financially more advantageous.

If the focus of the comparison between ICE and EV is on the cost per kilometer of fuel, it can be advantageous, but in a more holistic view, that is, the whole chain, it can be said that the total acquisition costs are as high or higher than the internal combustion engine..

7. SIMULATION OF FLEET ELETRIFICATION IN BRAZIL

In 2018, the fleet of Light Vehicles in Brazil reached more than 54 million [23]. Adopting the average 5% growth that occurred between 2010 and 2018 and projecting until 2030, we will have more than 98 million light vehicles, but it is also necessary to consider the vehicles that are no longer used, either by accident or by the useful life.

As we have seen previously, the global target for electrification of the fleet of light vehicles is 10%, which means 9.8 million EV as a possible target for the Brazilian fleet. This number distributed over the next 12 years would require around 818 thousand new EV per year in Brazil, which represents about 25% of new vehicles sold each year. For comparison purposes, in 2018, 3970 electric and hybrid vehicles were registered, the second with the largest representation [23] [24].

Considering a dollar quotation of R$4.00, the vehicles electrified up to US$50,000.00 or R$200,000.00 in Brazil are the hybrid Toyota Prius (US$31,375.00 or R$125,500.00), JAC iEV40 (US$35,000.00 or R$139,990.00), Renault Zoe (US$37,500.00 or R$149,990.00), Ford Fusion Titanium Hybrid (US$41,250.00 or R$164,900.00), Chevrolet Bolt (US$43,750.00 or R$175,000.00), Nissan Leaf (US$44,500.00 or R$178,400.00), BMW i3 (US$50,000.00 or R$199,950.00), Mini Cooper S hybrid (US$50,000.00 or R$199,990.00) [25].

Regarding the Brazilian vehicle market, there is a segment in which the electric vehicle competes, not for propulsion, but for comfort and status.

Of the total light commercial vehicles sold in Brazil in 2018 (2,099,606 units), the BMW, Lexus, Mercedes-Benz, Jaguar-Land Rover, Dodge, Chrysler and Audi brands sold 43,656 units, representing 2% of total sales of walking vehicles. Including Jeep sales, we reached a total of 150,608 units or 7% of that segment. Toyota sold 161,596 units in 2018, corresponding to 7.7% of sales of light vehicles and Honda, 131,601 units or 6.3% [23].

It is noted that current electric vehicle prices would compete with the premium brands on the market, and sales would scarcely reach 10% of total light vehicles sold if no tax benefit were implemented. For this to occur, these vehicles should compete with the brands that have products in the compact segment.

Considering that electric vehicles should reach the final retail value of US$20,000.00 or R$80,000.00 to be competitive in the Brazilian market, the most electric vehicle should account for a price reduction of 36%.

Today the fully electric imported vehicle had its import tax changed from 35% to zero, and electric hybrid vehicles have this tax between 2% and 7% depending on their efficiency [26]. The Industrialized Products Tax (IPI) varies between 7% and 20% according to the energy efficiency of electric and hybrid vehicles [27].

There is no history in Brazil in recent years of incentives with more than one digit of percentage in tax rates or subsidies for domestic vehicle acquisition (Table 3). This suggests that government strategies will hardly benefit imported electric vehicles based on the historic series of tax reductions if Brazil decides to meet the international VE participation targets in the national fleet by 2030, which provides for 10% of the electrified light vehicle fleet.

Table 3: History of tax cuts on vehicles manufactured in Brazil
[Source: Anfavea]

Year	Taxes	<= 1.0L	> 1.0L and < 2.0L		2.0L +	
			Gasoline C	FlexFuel	Gasoline C	FlexFuel
	ICMS	12	12	12	12	12
	PIS/Cofins	11,6	11,6	11,6	11,6	11,6
2007	IPI	7	13	11	25	18
	% Total	27,1	30,4	29,2	36,4	33,1
2008	IPI	***0***	***6,5***	***5,5***	25	18
	% Total	***22,2***	***26,4***	***25,8***	36,4	33,1
2009	IPI	**5,0/3,0**	**11**	**7,5**	25	18
	% Total	**25,7/24,4**	**29,2**	**27,1**	36,4	33,1
2010	IPI	**7,0/3,0**	**13**	**7,5**	25	18
	% Total	**27,1/24,4**	**30,4**	**27,1**	36,4	33,1
2011	IPI	7	13	11	25	18
	% Total	27,1	30,4	29,2	36,4	33,1
2012	IPI	***0***	***6,5***	***5,5***	25	18
	% Total	***22,2***	***26,4***	***25,8***	36,4	33,1
2013	IPI	**2**	**8**	**7**	25	18
	% Total	**23,6**	**27,4**	**26,8**	36,4	33,1
2014	IPI	**3**	**10**	**9**	25	18
	% Total	**24,4**	**28,6**	**28**	36,4	33,1
2015	IPI	7	13	11	25	18
	% Total	27,1	30,4	29,2	36,4	33,1

8. PRICE OF BATTERIES AND THE CHALLENGE OF ENERGY STORAGE

The storage of energy in electric cars has been the major technical and economic hindrance to the viability of these vehicles. As we have seen previously, these vehicles are only competitive with a high burden of tax incentives and exemptions, and do not always become more advantageous than their internal combustion engine alike. According to BloombergNEF [28], the price of batteries still corresponds to 33% to 50% of the price of electric vehicles.

However, the price of batteries has fallen a lot in recent years, from US$1,160.00 / kW in 2010 to US$176.00 / kW in 2018. This points to a price reduction of more than two-digit percentages each year. It is estimated that when the batteries reach the level of US$100 per kW, the electric vehicles will begin to be competitive with the vehicles of internal combustion. It is also estimated that this should happen around the year 2025 [28].

Another challenge to make the use of batteries viable is their inputs for manufacturing. Lithium, one of its main components, has its deposits concentrated in few countries. Bolivia, Chile, the

USA, Argentina and China, which are the countries with the largest reserves respectively, totaling 86% [21].

The case of Bolivia is somewhat different, although its reserves are the largest in the group, the United States Geological Service (USGS) does not consider them viable. The price of this product has also increased, in the year 2015 lithium carbonate presented a 15% increase over the previous year and has the projection of increase of more 75% by 2025 [29].

Another very important mineral in the manufacture of VE batteries is cobalt. It is estimated that 65% of all viable cobalt reserves are in the territory of the Democratic Republic of Congo in constant military conflicts. Another important point is the social impact of this activity. UNICEF in 2014 noted that about 40,000 children worked in Congo mines, many of them cobalt extraction. In 2017 Congo's largest mine, Tenke Fungurume, was acquired by a Chinese group [29].

The TESLA company predicts that if there are no investments in the mining areas for other elements needed for the batteries, besides lithium, such as nickel and copper, there will be problems in the manufacture of these accumulators for the near future [30].

Disposing of these batteries is also a major concern. Chemical recycling processes are complex, risky and expensive. The lithium-iron phosphate (LFP) battery predominates in China and has a life of 5 years. It is estimated that by 2020, 250,000 tons of batteries will be taken out of circulation. In Europe the challenge is the same, with only 5% of these batteries being recycled, the other 95% being incinerated or deposited in landfills [29].

However, it is possible to state that liquid fuels, such as ethanol, can also be considered as a battery because they have a high energy density and, consequently, store high amounts of energy. Ethanol has about 26.8MJ / kg while the maximum energy found in lithium-ion batteries is 2.43MJ / kg, that is, an energy storage advantage of more than 1000% [31].

9. CO2 EMISSIONS OVER THE VEHICLE'S LIFE

An increasingly debated issue is the environmental impact of vehicle manufacturing and operation. With the diversification of propulsion models and their apparent immediate benefits, this analysis becomes more necessary for the modal decision taken by governments to have a more complete view.

The study of FEV Group Europe GmbH of 2018 compared the models of vehicles with internal combustion engines with spark ignition (SI), vehicles with internal combustion engines with ignition from fuel compression (CI), hybrid electric vehicle variants associated with internal combustion engines (HEVs), vehicles with electric motors exclusively powered by battery (BEV) and fuel cell electric vehicles (FCV) [32].

In this study CO2 emissions were calculated for each of the types of vehicles analyzed in the production phases of the vehicle including the battery, the production of an extra battery, the transport of the fuel used and the consumption for 168,000 kilometers. The study conducted took into account the German energy matrix of 2012, which still emits a lot of CO2 by burning non-renewable fuels for electric power generation, as well as the gasoline and diesel of that country [32].

The result showed that the fuel-only vehicle (SI) is the second most polluting, second only to the battery-powered electric vehicle (BEV). Third is the hybrid vehicle powered by gasoline (SI HEV) followed by the diesel vehicle (CI). The fifth most polluting is the internal combustion engine that uses a fuel that recovers 30% of the CO2 emissions, as is the case of corn ethanol, widely produced in the USA and in sixth place is the vehicle propelled by the hybrid engine at diesel (CI HEV).

In the sequence we have values very close to the vehicle with internal combustion engine driven biodiesel with recovery of 30% of CO2, and then the electric vehicle moved to the battery charged with electric energy coming from 50% of zero carbon sources, such as solar, wind or hydroelectric plants. In ninth place we have the electric vehicle to the battery charged with 100% electricity free of emissions of CO2 gases. In the last three places are the vehicles with the lowest CO2 emissions in their life cycle, where they occupy the internal combustion vehicles that use biodiesel with 90% CO2 reabsorption and ethanol from sugarcane, as is the case of Brazil, losing only for the fuel cell vehicle that uses hydrogen to generate electricity [32].

By analyzing the monetary cost of energy for transportation, the electric vehicle offers a great benefit as it is more efficient and has a low cost per kilometer, but the dependence of non-renewable and GHG sources on the generation of electricity in most developed countries generates a high ecological cost. This study shows the strong impact of Brazilian sugarcane ethanol as one of the best options for the transport sector to reduce CO2 in the atmosphere, thus achieving greenhouse gas reduction targets and commitments to COP21 and the global climate.

10. ANALYSIS AND DISCUSSIONS

It was observed that transport is not the major emitter of GHG in Brazil, as it is in most developed countries, and that the greatest gains in reducing these gases will be obtained through actions in sectors such as land use change and agriculture, land education, education in the field, tend to significantly reduce CO2 emissions in the country. Although the transportation sector is not the most polluting in Brazil, it is the medium with the most CO2 emissions within the energy sector. Within this context, we observed that the greater use of ethanol in light vehicles has a representative contribution in reducing GHG.

Brazil has a leading position in clean energy generation because almost half of all Brazilian energy matrix is renewable, and more than half of this is biomass, with more than 40% coming from sugarcane products. The sugarcane plantation reabsorbs 89% of the CO2 emitted in the whole process of production and consumption of biofuel ethanol. It is verified that the production of sugarcane in Brazil does not compete with the production of food. It can be analyzed that if the area for current ethanol production were doubled, the fleet of light vehicles could be completely fueled with ethanol. The new sugarcane variety associated with the new second generation ethanol production process will be able to double ethanol production to the same area currently used for sugarcane in the coming years.

We can observe in parallel that the developed countries, because they do not have many options for renewable energy like Brazil, have to go to other ways to reduce GHG, such as reducing energy consumption. Since the transportation sector is one of the most polluting sectors of most developed countries, more efficient solutions such as the electric car are adopted. The electric vehicle is often more expensive than similar domestic combustion, even with government incentives, and that even with a strong growth in world sales, EV stocks are far from meeting international targets to make up 10% of the light vehicle fleet.

If Brazil chooses to follow the path of electrification of the light vehicle fleet, the target should be 25% of light vehicle sales, and for that it should compete in the category of the most popular cars. Compared with current prices in the Brazilian market, the LV should receive government financial incentives that are many times greater than those already practiced in previous years.

To produce batteries to meet this demand, there are difficulties in obtaining inputs for production, as well as a challenge of disposal in a sustainable way. It can also be verified that this component is responsible for the high value of the VE. It is noted that ethanol can be considered a battery because it is a renewable fuel, and it carries much more energy by the same unit of weight.

Finally, throughout the entire life cycle of electric vehicles, they can even emit more GHG compared to their combustion-like ones, depending on the source of the electrical energy that charges their batteries and produce their components. In the same context, the ethanol-fueled internal combustion vehicle is one of the least polluting within the complete product life cycle.

11. CONCLUSIONS

Ethanol is shown throughout the analysis presented the best option to achieve the results of CO2 reduction in Brazilian transports from a wide perspective from its production to the use as fuel. The fact that no adaptation is necessary in the current mode of transport has a great advantage and justifies that this model is continued. With the fleet of more than 90% of light vehicles able to travel with both C-gasoline and ethanol in any proportion (FlexFuel vehicles), one of the few challenges is that the price of ethanol is more advantageous for the final consumer.

Developed countries, because they do not have a renewable energy matrix, turn to other solutions, often more expensive, like the electric vehicle that has better efficiency by emitting less GHG by the same distance traveled in comparison to the VCI driven by fossil fuels. But a full life cycle analysis of this vehicle may show that it can be a major emitter of GHG depending on its energy source and manufacturing inputs. In addition, the proposal to electrify the Brazilian fleet is much more costly and tends not to bring such high gains of CO2 reduction compared to ethanol, in an analysis from the beginning to the end of the life of the vehicle.

In addition, Brazil has the opportunity to expand and increase its ethanol productivity. Considering the energy efficiency of electrification as a consensus it is possible to add value by electrifying a vehicle and generating energy from the use of ethanol, from technologies such as hybridization and fuel cells.

To conclude, this article aimed to evaluate the GHG reduction proposals focused on the iNDC targets. Regarding the emissions of pollutants, either by evaporative or post-combustion emissions generated by ethanol and / or fossil fuels, they have not been analyzed and require an analysis to complement this article.

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