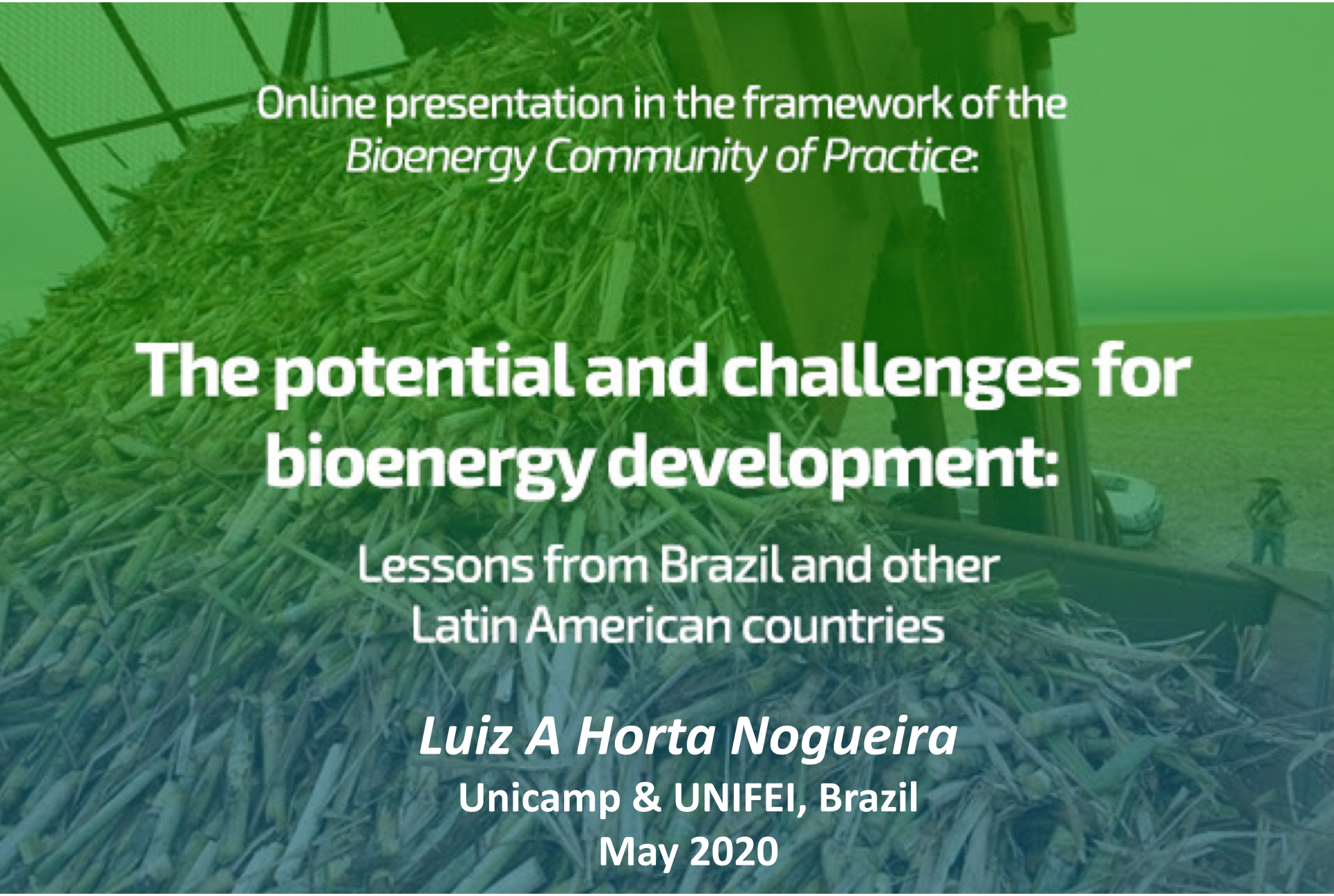


Online presentation in the framework of the
*Bioenergy Community of Practice*:

# The potential and challenges for bioenergy development:

## Lessons from Brazil and other Latin American countries

***Luiz A Horta Nogueira***
**Unicamp & UNIFEI, Brazil**
**May 2020**

# *The potential and challenges for bioenergy development in Latin America & Caribbean*

***Outline***

- ✓ ***Bioenergy and biofuels: evolution and context***
- ✓ ***The Brazilian experience on ethanol from sugarcane***
- ✓ ***The potential of Latin America and the Caribbean***
- ✓ ***The Renovabio program***
- ✓ ***Final remarks and Q/A***

# *Bioenergy: our first energy resource*

***Biomass was the first energy source used by mankind and our main source of energy until the last century.***

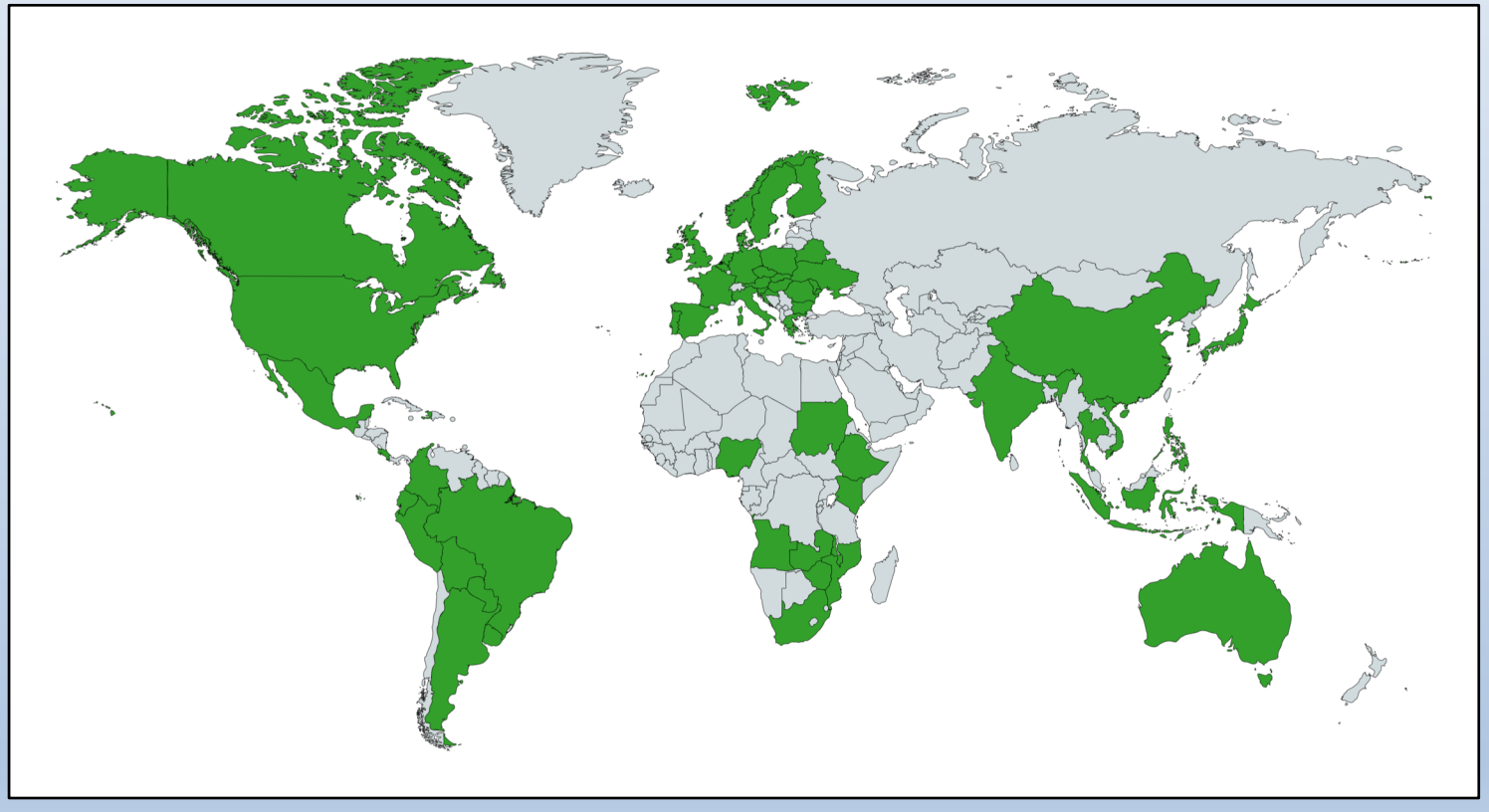
***More recently, due to economic, environmental and energy security reasons, there is a growing interest in bioenergy, mainly as liquid biofuels and bioelectricity.***

*The quest for fire*, J.J Arnaud, 1981

# *Biofuels use expands globally.*

***Several countries have national programs fostering the use of biofuels, typically in blends with conventional fuels and in some countries promoting also the use of pure biofuels.***

**Countries adopting biofuels blending mandates**



(BiofuelsDigest, 2018)

# International Energy Agency perspective

International Energy Agency | About | News & Events | Analysis | Our Work | Countries | Statistics & Data | Русский | 中文网页

Home » Newsroom » News » 2018 » October

## Modern bioenergy leads the growth of all renewables to 2023, according to latest IEA market forecast

8 October 2018

*Bioenergy remains the largest source of renewable energy because of its widespread use in heat and transport, sectors in which other renewables currently play a much smaller role (Photograph: Shutterstock)*

Share

Related report

**Market Report Series: Renewables 2018**
The annual IEA market analysis and forecast on renewable energy

Latest articles

Hydrogen, the missing link in the energy transition


***Is there really a food versus fuel dilemma?***

# *There is no lack of food, there are people not able to access food.*

***Obesity** is currently a more serious problem than hunger in most countries.*

***Effectively, there is no shortage of food, there is lack of access to food resources, most due to poverty of some social groups.***

***The growing food waste indicates the untapped surplus production.***


The Lancet, Volume 378, Issue 9793, Pages 804 - 814, 27 August 2011

## The global obesity pandemic: shaped by global drivers and local environments

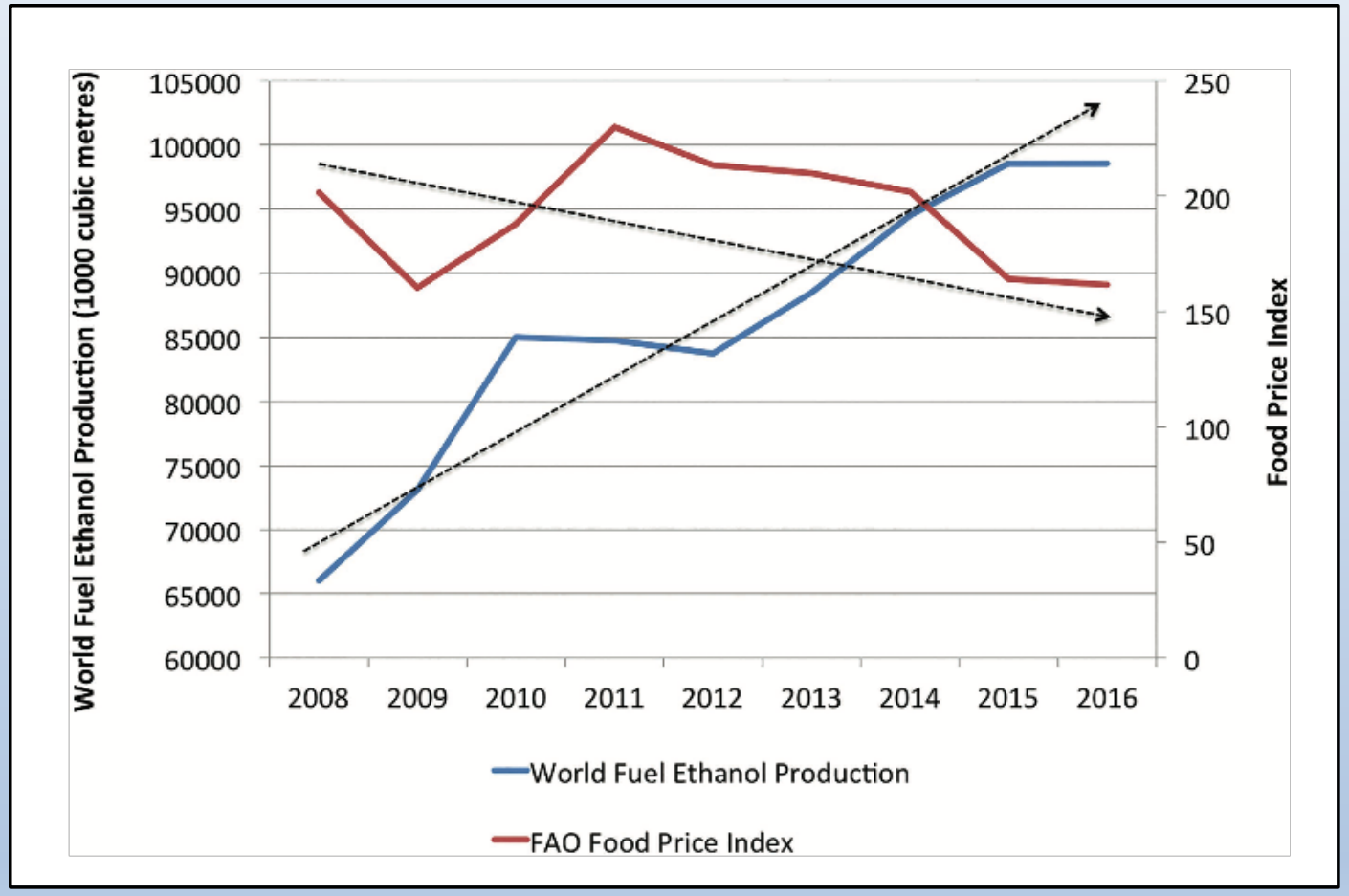
Prof. Boyd A Swinburn MD a , Gary Sacks PhD a, Kevin D Hall PhD c, Prof Klim McPherson PhD d, Prof Diane T Finegood PhD e, Marjory L Moodie DrPH b, Prof Steven L Gortmaker PhD.

Summary

The simultaneous increases in obesity in almost all countries seem to be driven mainly by changes in the global food system, which is producing more processed, affordable, and effectively marketed food than ever before. This passive overconsumption of energy leading to obesity is a predictable outcome of market economies predicated on consumption-based growth. The global food system drivers interact with local environmental factors to create a wide variation in obesity prevalence between populations…

# Biofuels and food prices

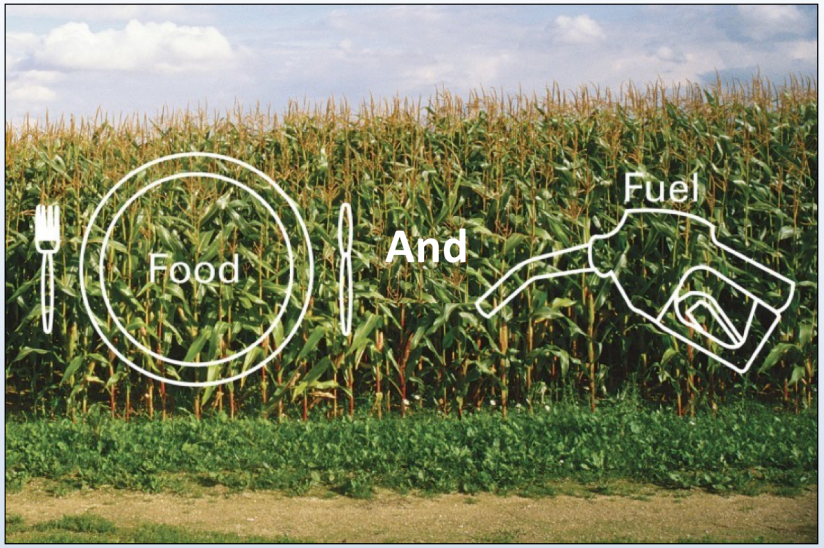
***Detailed studies indicate a small impact of biofuels production on availability and cost of food.***




**World ethanol fuel production and FAO Food Price Index**

(Rosillo-Calle, 2018)

***The opinion of the FAO, United Nations Organization for Agriculture and Food, on biofuels and food***




**We have to move from the food versus fuel debate to a debate on food and fuel."**

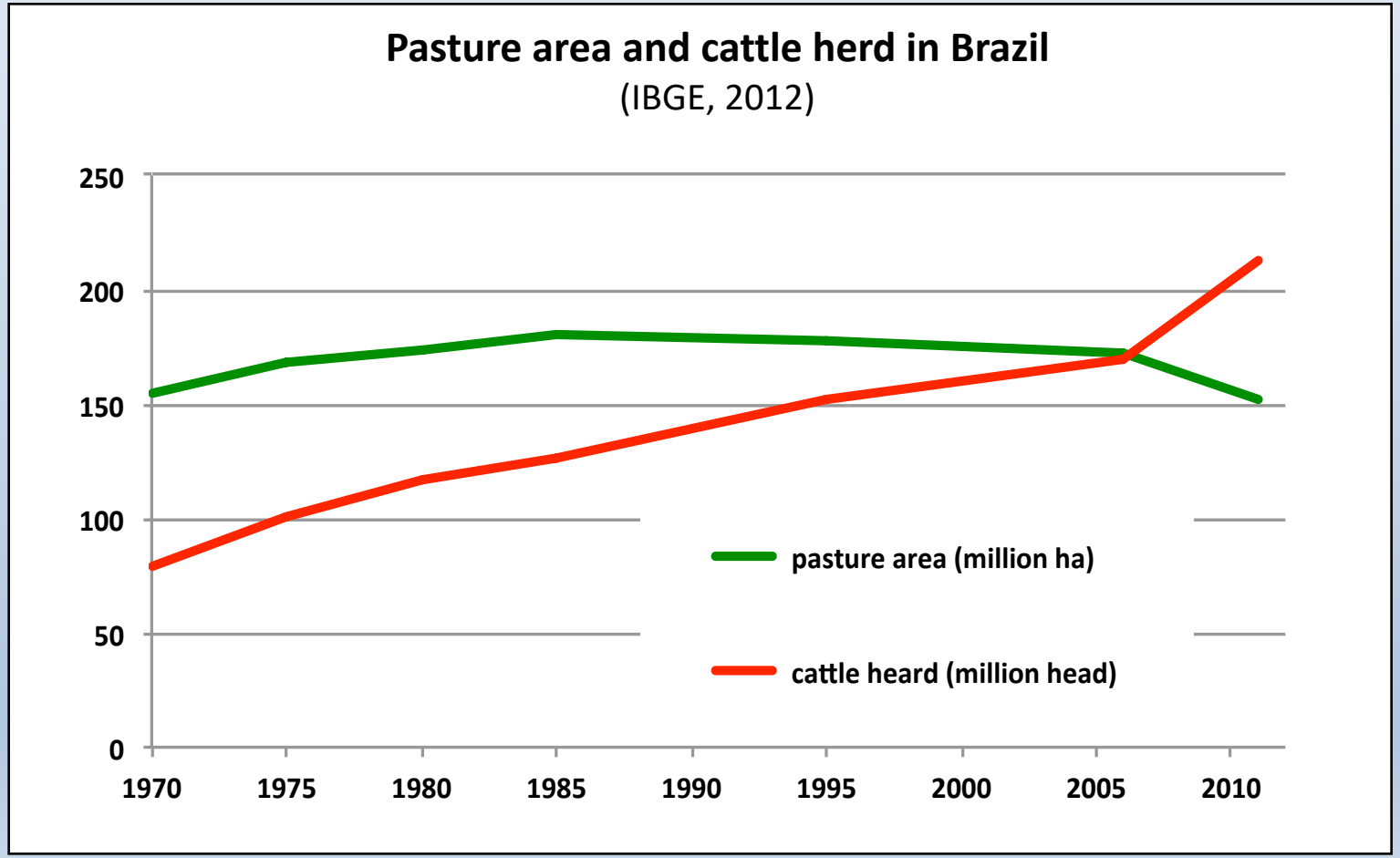
*J.G. Silva*, FAO General Director

**Global Forum for Food and Agriculture**

Berlin 2015

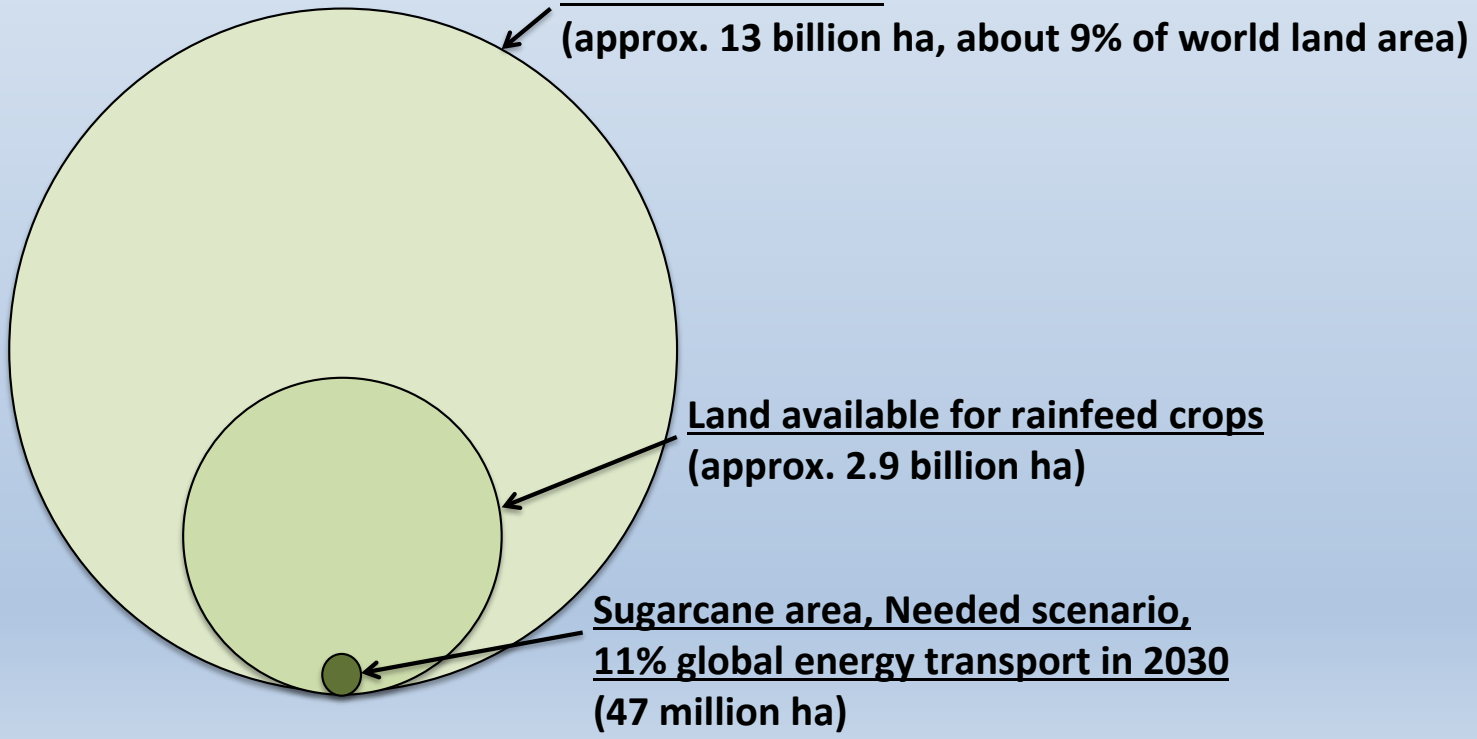
# Food and Biofuels

***Improvement in agriculture productivity and pasture intensification open land for biofuel production.***



# *There is more than enough land to promote bioenergy production*

***The land to be planted with sugarcane to produce ethanol enough to replace 11% of expected global demand of gasoline 2050), means 1.6% of land available for rain fed agriculture, mostly in Latin America and Africa (FAO/GAEZ, 2012).***



# *Sugarcane: an excellent feedstock for ethanol*

***Sugarcane, a traditional culture almost all tropical countries, is:***

- ***one of the most efficient solar energy converter to biomass, a feedstock of choice for bioenergy production.***
- ***a semi-perennial crop, planted once and harvested annually for 5 to 6 years.***

***As a whole, 1 ton of sugarcane is equivalent to 1.2 barrel of petroleum, thus:***

***one hectare of sugarcane produces more than 100 barrels of oil per year, during many years...***

# *The sugarcane agroindustry*

***Ethanol and sugar are produced jointly from the sugarcane juice, while the bagasse is used as fuel in cogeneration schemes to produce electricity.***

***Considering all direct and indirect energy costs, each unit of fossil energy produces 8 to 10 units of renewable energy.***

***Despite of the intense mechanization of planting and harvest, sugarcane still requires much more human labor than any other energy technology.***

**A typical sugar and ethanol mill in Brazil**
(BNDES, 2009)

# *Applied knowledge fosters sustainability*

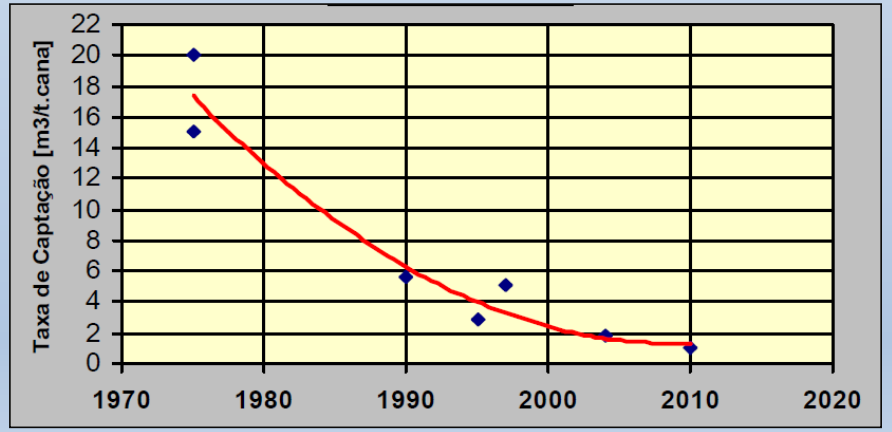
***R&D and innovation, has been essential for improving bioenergy.***

***Some cases:***

**Use of vinasse as fertilizer**
(UNICA, 2008)

**Biological control of sugarcane borer (*Diatraea saccharalis*) using a wasp (*Cotesia flavipes*)**
(Bento, 2006)

**Power generation from sugarcane bagasse**
(UNICA, 2006)




**Evolution of water use in sugarcane mills in Brazil**
(Elia Neto, 2010)

# *Frontiers developments in sugarcane bioenergy*

***Innovation have always played an important role to improve the sugarcane bioenergy agroindustry, increasing its sustainability in all aspects. Ethanol can be produced even more efficiently.***

***Opportunities for improvement:***

- ***Sugarcane trash recovery and utilization***
- ***Energy cane***
- ***Second generation ethanol processes***
- ***Precision agriculture***
- ***Biogas production from stillage, and other.***

**2G ethanol plant Alagoas, Brazil** (Granbio, 2016)

**Energy cane (at left) and commercial sugarcane (at right) at 90 days after planting** (Carvalho-Netto et al., 2014)

# *Liquid biofuels are not a newcomer*

***Biofuels were used in the early days of the automotive industry: Rudolf Diesel suggested the use of peanut oil in his engine, and Henry Ford was a strong advocate of ethanol, producing specific models for this biofuel.***

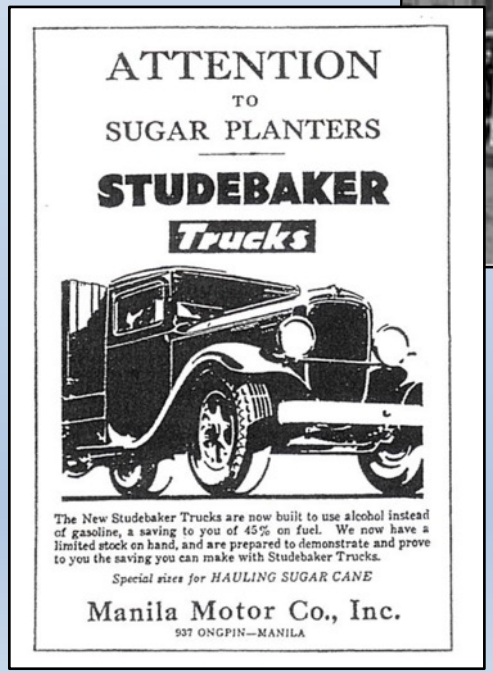
**Congrès des Applications de l'Alcool Dénaturé (catalogue), Automobile Club de France, 1902**

**Henry Ford driving a vehicle on pure ethanol in 1896**

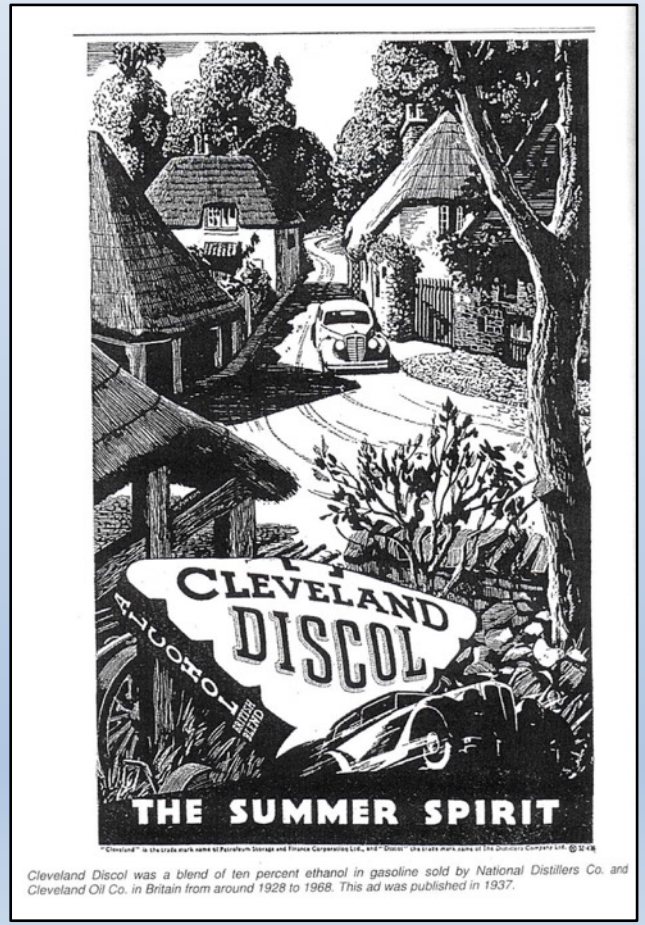
# *Liquid biofuels are not a newcomer*

***From the good results achieved since 1890 in the USA, France and Germany, in the beginning of the last century ethanol was regularly adopted in many countries, pure or in mixtures.***

**Gas station, United States,1933**


**Advertisement of pure ethanol truck, Philippines, 1928.**



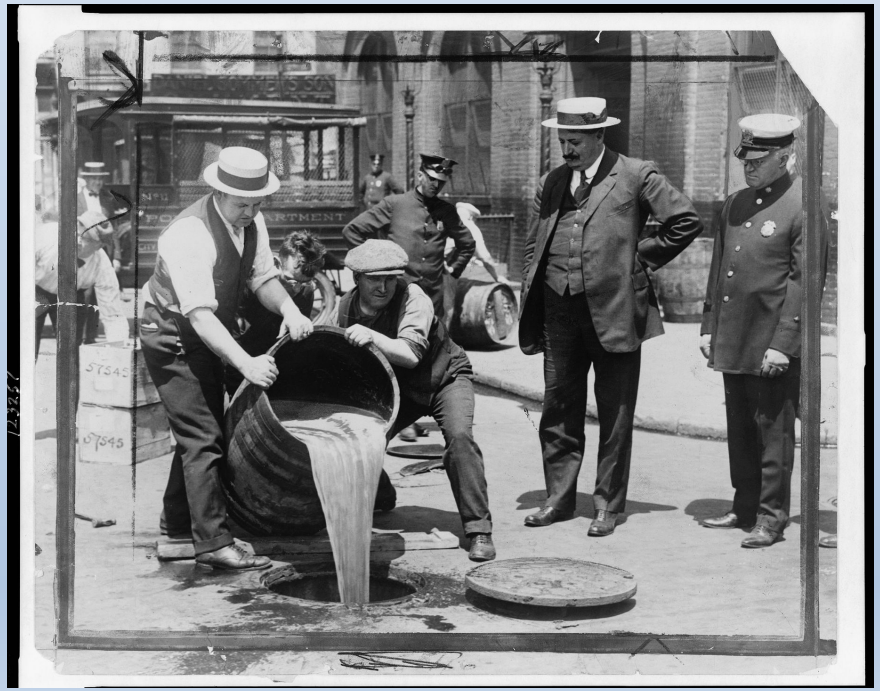

**E10 fuel advertisement, marketed in England between 1928 and 1968.**

# *Why didn't biofuels remain?*

***The low prices of gasoline and the pressure of oil companies was decisive for the progressive abandonment of the use of ethanol.***

***In the USA, the Prohibition also played an important role, hindering the regular trade of alcohol between 1920 and 1933. Only in Brazil, India and the United Kingdom* the use of fuel ethanol has been maintained since then until now.***


*(until 1968)



*Removal of liquor during Prohibition.*

# Electric cars are coming… will they use ethanol?

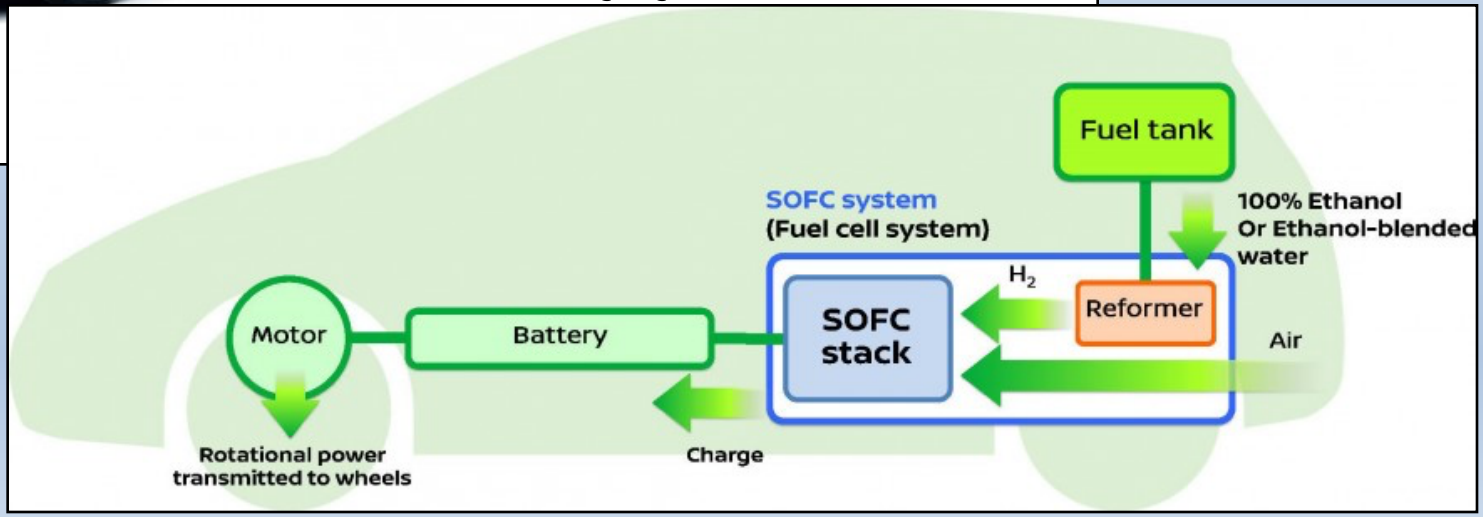
## e-Bio Fuel Cell

NISSAN

- Uses 100% ethanol, which is already widely available in Brazil, as fuel


Specifications of research prototype vehicle

| Features | Specs. |
|---|---|
| Base vehicle | e-NV200 |
| Battery Capacity | 24kWh |
| Powertrain | Electricity |
| | 100% Ethanol |
| Fuel tank capacity | 30L |
| SOFC power | 5kW |
| Driving range | Over 600km |



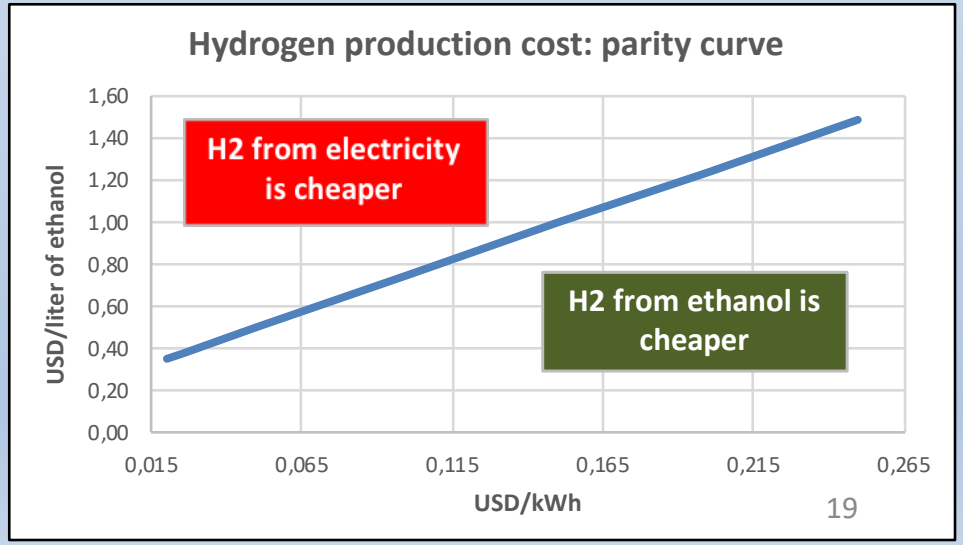
# Electric Vehicles work better with biofuels

- ✓ *Ethanol has better combustion properties compared with gasoline (High Octane Fuels (DOE) and Advanced Motor Fuels (IEA) programs)*
- ✓ *Automotive industry is launching improved cars and engines operating with ethanol and very low GHG emission.*
- ✓ *Hydrogen from ethanol is cheaper and easy to make than using electricity.*

**Toyota Corolla HEV FF, < 20 gCO2/km**


**Nissan e-Bio, FC and reformer**

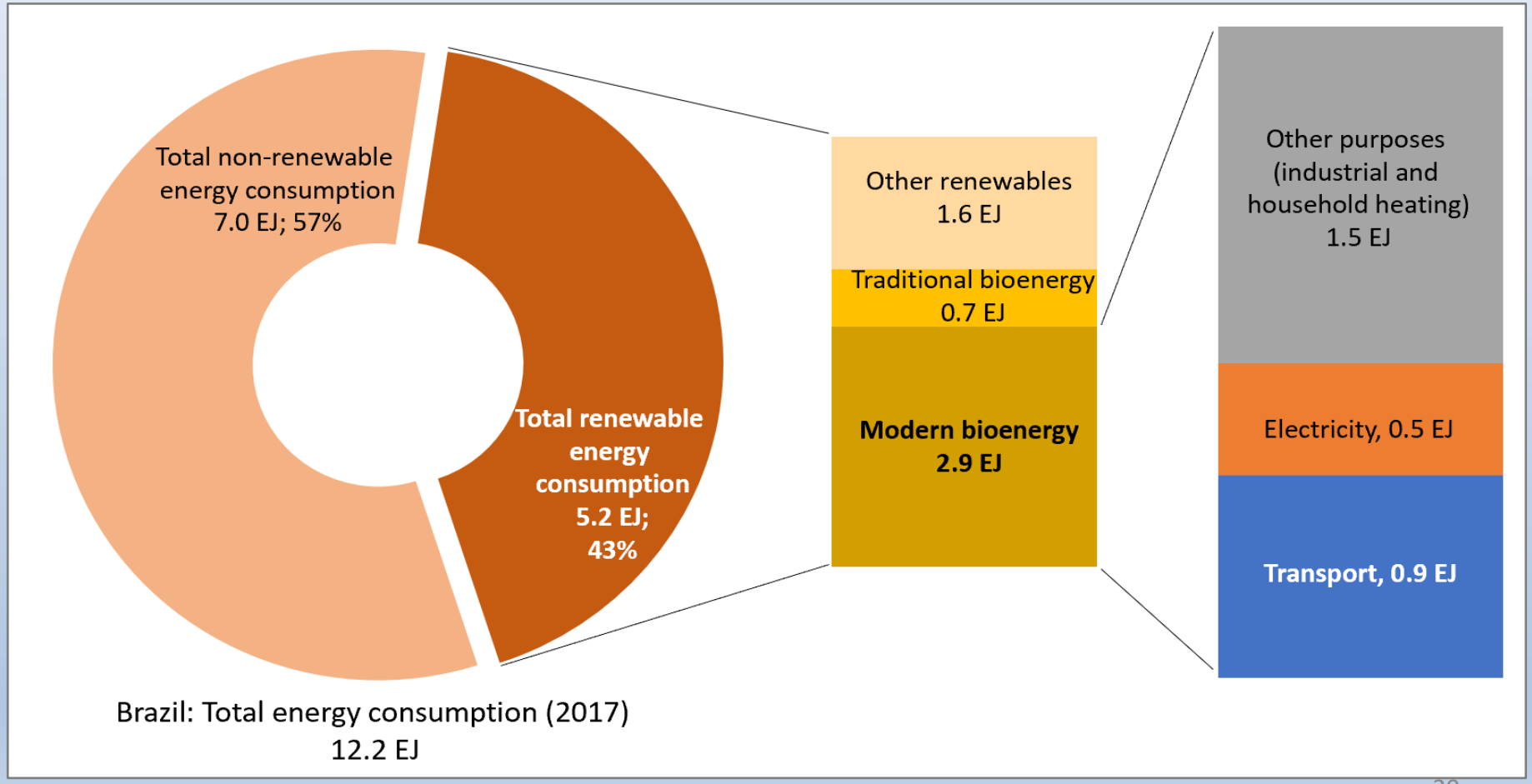
**Hydrogen production cost comparison**



# *Brazilian Energy Matrix*

***Biomass is the main renewable source of energy in Brazil.***

***Sugarcane (as ethanol and electricity), wood and vegetable oils represent about 24% of total energy supply.***



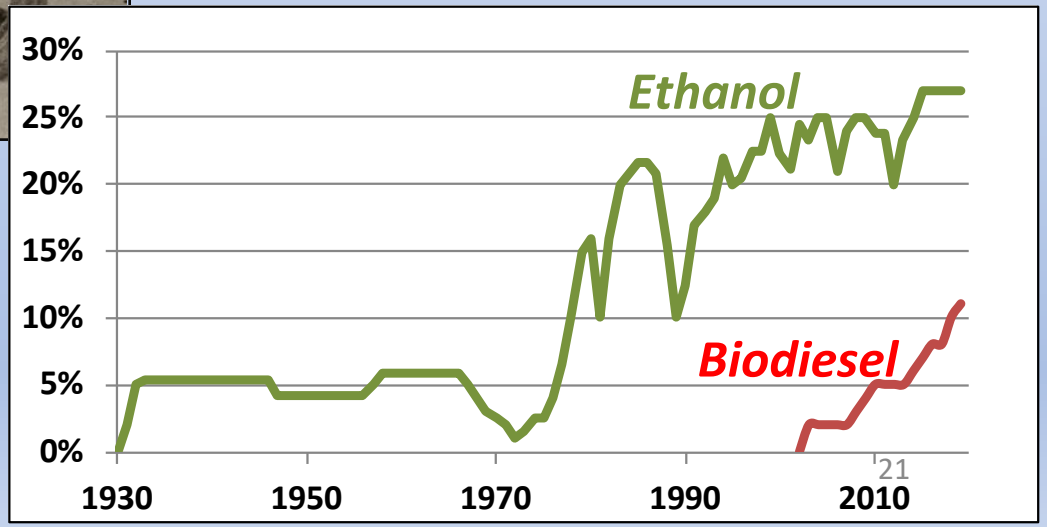

(Nogueira et al., 2019)

# *Biofuel use in Brazil: the initial steps*

***Gasoline blended with ethanol has been a mandatory practice in Brazil since 1931, reinforced after the oil crisis during the 70's, when high blends (currently E27) in all gasoline and pure hydrous ethanol (for dedicated motors) were adopted.***


(INT, 2006)

**Ford Model T adapted for pure ethanol, used for public demonstrations in Brazil during the 20's**




**Evolution of % ethanol in gasoline and % biodiesel in diesel in Brazil**

(BNDES, 2009, updated)

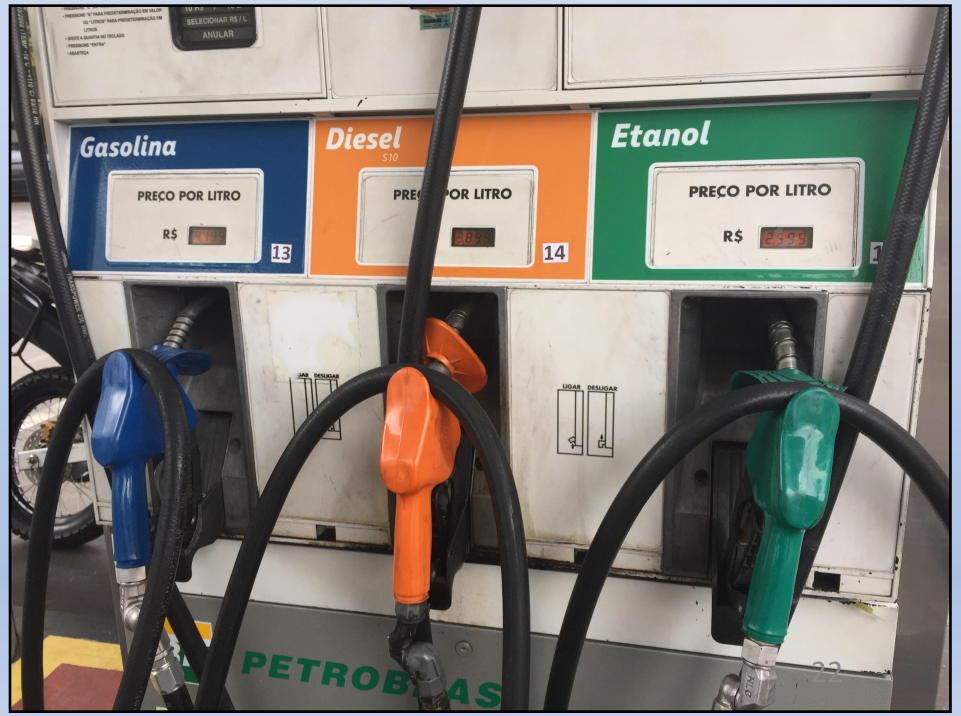
# ***Biofuels can reduce carbon emissions now.***

***All Brazilian gas stations sold only:***

- ***Gasoline E27***
- ***Pure ethanol E100***
- ***Diesel B12***

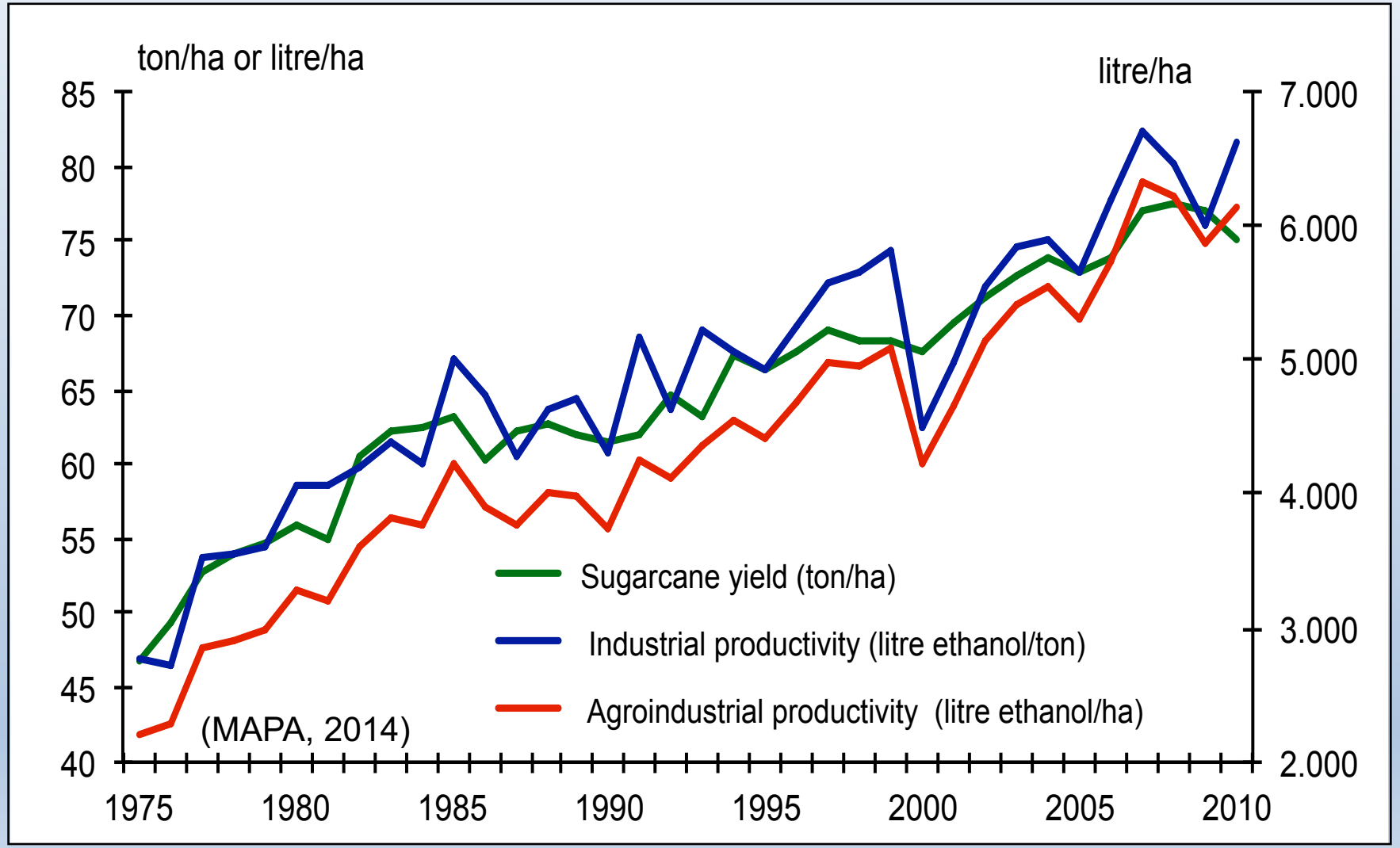
***Since 2003, about 535 million tons of CO2 were not emitted in Brazil due to the use ethanol substituting gasoline.***

***The same could happen in many other countries.***



# Agro-industrial technology evolution

***Improvements in sugarcane production, logistics and processing allowed an 260% increase in yield and 70% reduction in costs.***



# *Bioenergy potential in LAC*

***Latin America and the Caribbean present excellent conditions to produce bioenergy.***

***About 360 million ha of land suitable for rain fed agriculture are available for expanding agriculture in LAC (FAO, 2012); 37% of global total and more than 3X the area required to meet future world food needs.***

***20% of this area, properly managed and using efficient processes can produce annually 24 EJ of liquid biofuels, equivalent to 11 million bpd of oil, more than current US or Saudi Arabia production.***

***This biofuel will avoid the emission of 1,58 billion tons of CO2eq per year.***

Renewable Energy 121 (2018) 164–172

Contents lists available at ScienceDirect

Renewable Energy

journal homepage: www.elsevier.com/locate/renene

# Sugarcane can afford a cleaner energy profile in Latin America & Caribbean

Simone Pereira Souza [a, *, 1], Luiz Augusto Horta Nogueira [a], Johan Martinez [b], Luis Augusto Barbosa Cortez [c]

[a] Interdisciplinary Center for Energy Planning - NIPE, University of Campinas - UNICAMP, P.O. Box 6166, 13083-896 Campinas, São Paulo, Brazil
[b] Asociación Nacional de Cultivadores de Caña de Azúcar, Calle 58 Norte, 3N 15, Cali, Colombia
[c] Faculty of Agricultural Engineering - FEAGRI, University of Campinas - UNICAMP, P.O. Box 6011, 13083-970 Campinas, São Paulo, Brazil

ARTICLE INFO

*Article history:*
Received 5 July 2016
Received in revised form
1 January 2018
Accepted 9 January 2018
Available online 10 January 2018

*Keywords:*
Sustainability
Biofuel
Bioelectricity
Developing countries

ABSTRACT

Latin American and Caribbean's (LAC) external dependency on fossil fuels and the pursuit for renewable energy leads to the need for a strategy to afford a cleaner and reliable domestic energy supply. Sugarcane presents high photosynthetic efficiency and it is a well-spread crop in LAC. Our study aims to explore the potential of different approaches of modern energy production from sugarcane, at a national level, and its implication to the environmental aspects. We found that Guatemala, Nicaragua and Cuba would be able to replace 10% of the gasoline and about 2–3% of the diesel consumption by only using the current molasses. With a slight expansion on sugarcane production, Bolivia can replace 20% of the gasoline and diesel, besides providing surplus ethanol for exportation or other purposes. With a minor investment, bagasse may enlarge the electricity access in many countries whereas in other may represent an alternative to replace fossil fuel sources. We also found relevant potential on reducing the GHG emissions specially in Bolivia, Paraguay and Nicaragua. However, the implementation of such strategies must be supported by appropriate policies to ensure competitive prices, overcome opportunity costs, and stimulate investments.

# *Sugarcane bioenergy potential in Latin America & Caribbean*

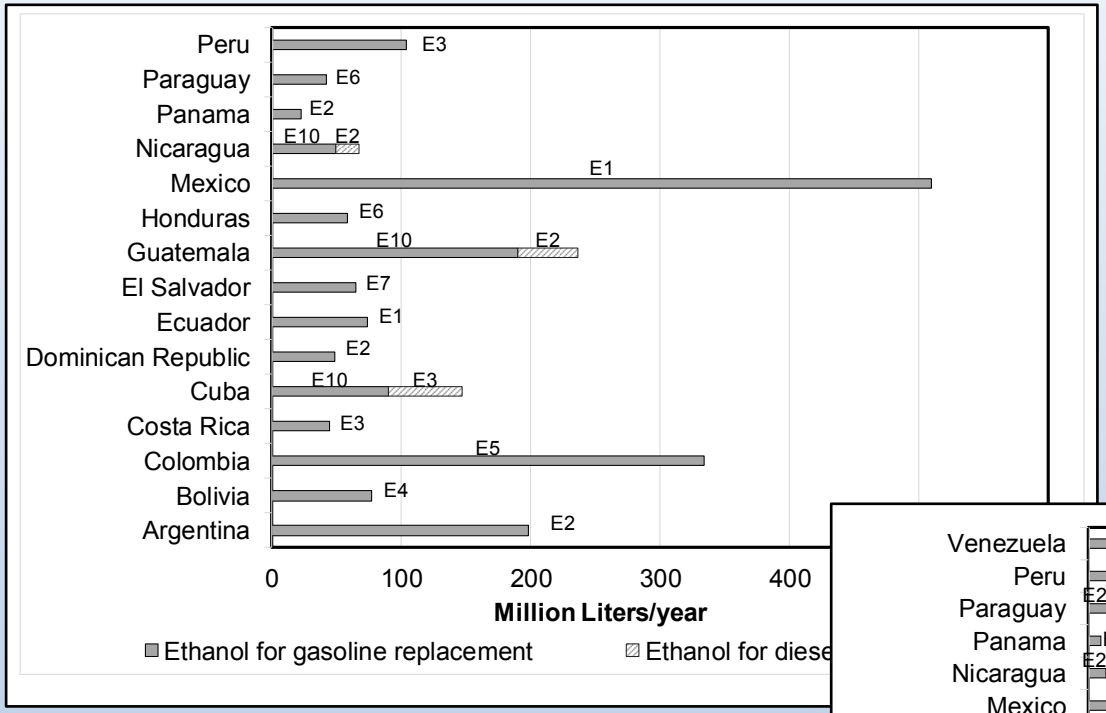
## Basic Assumptions

| Parameters | Mature Context | New Framework |
|---|---|---|
| Mill crushing capacity (t/year) | $10^6$ | 106 |
| Ethanol yield from molasses (L/t cane)[a] | 10 | 10 |
| Ethanol yield from direct juice (L/t cane)[b] | Not applied | 80 |
| Ethanol source | Molasses | Molasses and juice |
| Pasture area allocated for sugarcane cropping[c] | 0% | 1% |
| Surplus electricity (kWh/t cane)[d] | 30 | 80 |
| Gasoline replacement limit | 10% | 20% |
| Diesel replacement limit | 10% | 20% |

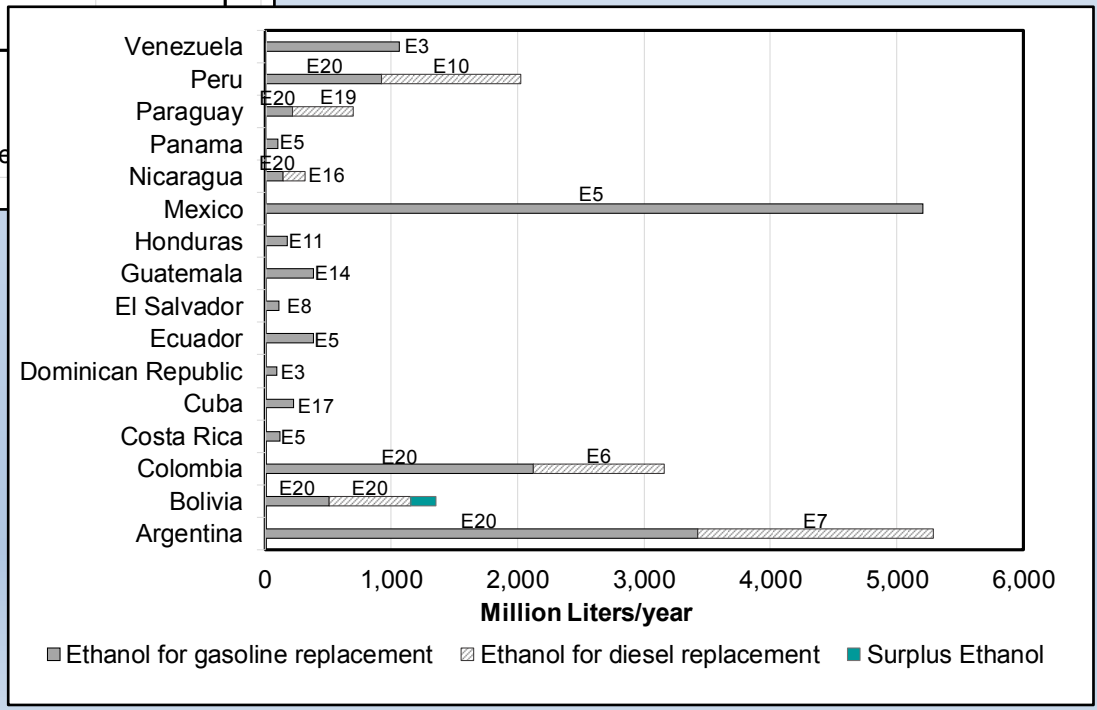
[a] Data from United Nation [35].
[b] Average from Brazilian South-Central region [36].
[c] Available pasture land according to FAOSTAT, http://faostat.fao.org [37].
[d] Ethanol distillery consumes 30 kWh/t cane (mechanical and electrical energy) [38]. Electricity production in the MC and NF scenarios are 60 kWh/t cane (42 bar, 450 °C) and 110 kWh/t cane (65 bar, 480 °C), respectively [30].

# *Sugarcane bioenergy potential in Latin America & Caribbean*

## Ethanol supply and use in LAC




**Mature Context**




**New Framework**

# Public communication and information is relevant

***In some cases, a wrong perception by the public and government of risk in using ethanol is a relevant barrier to implement ethanol use.***

***For instance, Guatemala produce and export large amounts of ethanol; adopting E10 blend could reduce gasoline imports, generate jobs, and other advantages. However, there are persistent concerns about the technical feasibility of ethanol blends.***

***A demonstration program was launched to clarify these aspect***

Plan Piloto de Etanol

| Modelo | Cantidad |
|---|---|
| 2011-2014 | 2 |
| 2000-2010 | 12 |
| 1990-1999 | 6 |
| 1986-1989 | 2 |
| 1985-menor | 3 |
| motocicletas | 5 |
| TOTAL | 30 |

**Fleet composition, Guatemala demo plan, 2015**

# *RenovaBio Program*

***Launched in 2017 by Law 13.576 as the Brazilian National Biofuel Policy, RenovaBio aims:***

- ***promote GHG emission mitigation, in line with Brazilian targets set in COP21.***
- ***foster bioenergy agroindustry, improving energy security and with positive impacts on income and jobs generation.***

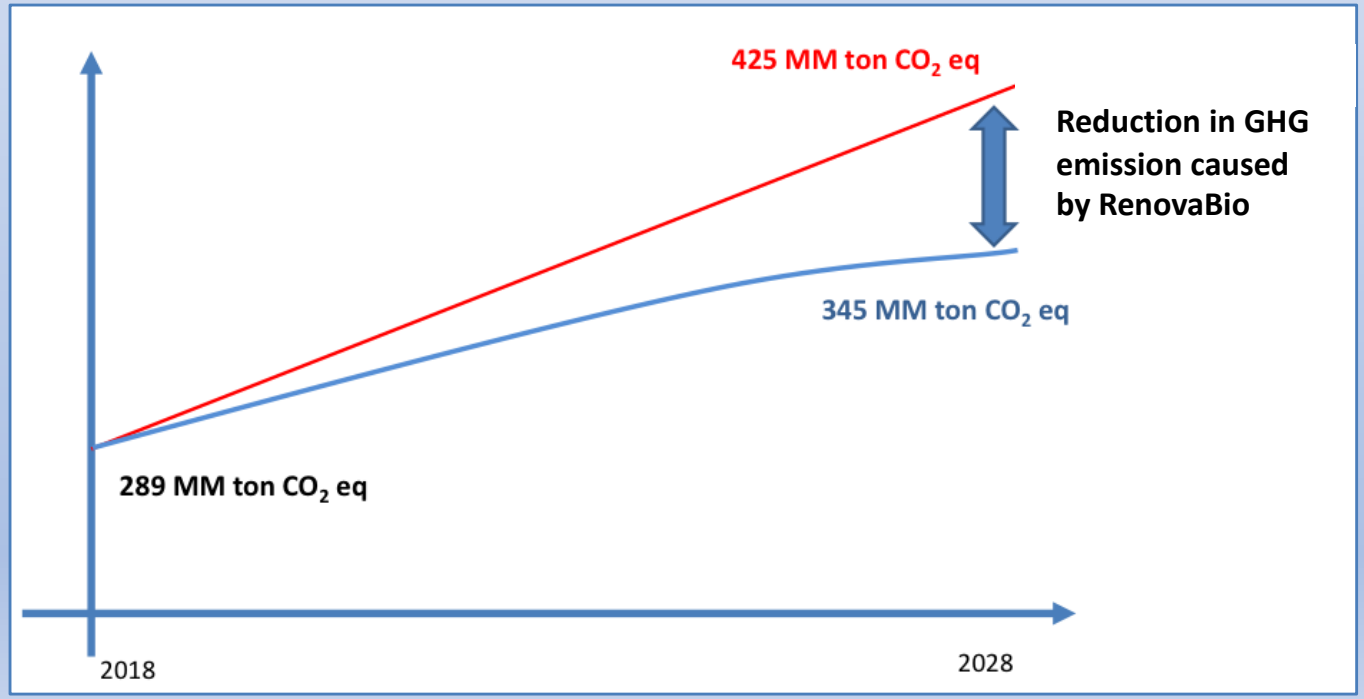
***RenovaBio is founded on three pillars:***

- ***Annual decarbonization targets set by the government for a ten years period, to be accomplished by fossil fuel distributors.***
- ***Issuance of CO2 emissions reduction certificates, named "CBio" (a Decarbonization Credit) by biofuel producers.***
- ***CO2 emission in biofuels production is evaluated through Life Cycle Analysis (LCA), as certified by qualifying agencies for each producer unit.***

# *RenovaBio: decarbonization targets*

***Considering the Brazilian NDC in COP21 (-43% GHG emission) and all measures adopted for mitigating emissions, the National Council of Energy Policy set a target for the transport sector: to release less 80 million tonnes CO2eq in 2028.***

***This target was distributed in 10 years and shared among fossil fuels distributors, as a mandatory GHG emission compensation. It corresponds to decrease the average specific emission (carbon intensity) of energy used in transport from 73.5 to 69.0 gCO2eq/MJ between 2018 to 2028.***




**Projection of GHG emission from transport in Brazil (MME, 2018)**

# *RenovaBio: GHG emissions reduction certificates*

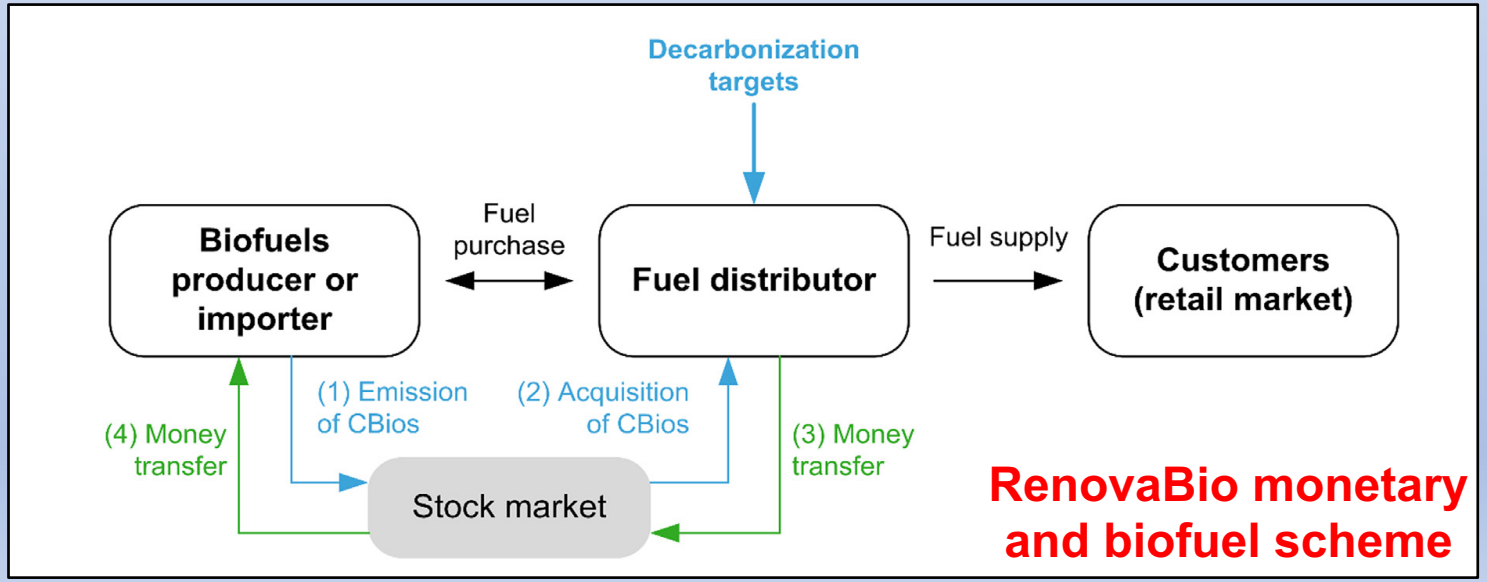
***To compensate their emission, fossil fuel distributors should buy CBIO bonds (decarbonization credits) on the Stock Market, issued by certified biofuel producers.***

***Each CBIO corresponds to one tonne of fossil CO2 no emitted due to biofuel use. For example, using specific emissions:***

***gasoline : 86.0 gCO2 eq/MJ (baseline)***
***hydrous ethanol : 20.8 gCO2 eq/MJ (typical figure for sugarcane mill)***
***mitigation : 65.2 gCO2 eq/MJ.***

***In this conditions, each liter of ethanol mitigates about 1.2 kg of CO2; thus, one tonne of fossil CO2 is mitigated when 833 liters of ethanol replace gasoline.***






**RenovaBio monetary and biofuel scheme**

**(Klein et al., 2019)**

# *RenovaBio: biofuel LCA emissions certification*

***As a crucial process in Renovabio, every biofuel producer must verify its environmental performance and certify its "well-to-wheel" LCA emission.***

***With this aim, it was established:***

- ***a LCA calculation scheme (RenovaCalc),***
- ***rules of accreditation of certification firms eligible to certify producers,***
- ***the procedure to be adopted for biofuel companies, which includes public hearing and open consults.***

***Renovacalc, the open access spreadsheet implemented to calculate the Carbon Efficiency of biofuel producers, was developed by respected research institutes, active in bioenergy and experienced in LCA. Lower emissions are associated to best practices, high yields, byproducts recycling (eg. biogas production and fertilization with vinasse), rational inputs use, high pressure cogeneration, etc.***

*(http://www.anp.gov.br/producao-de-biocombustiveis/renovabio/renovacalc)*

RenovaCalc

RenovaBio

Instruções

## DIRETÓRIO DE ROTAS DE PRODUÇÃO DE BIOCOMBUSTÍVEIS

**Tipo de preenchimento**

Tipo de dados forneceidos pela usina:

Padrão

**Área Queimada**

| | | |
|---|---|---|
| Área queimada | 20.000 | ha |

**Primários**

**Corretivos**

| | | |
|---|---|---|
| Calcário calcítico | 0,00 | kg/t cana |
| Calcário dolomítico | 8,11 | kg/t cana |
| Gesso | 3,91 | kg/t cana |

Bioque

### Produção de Etanol de cana-de-açúcar

| | |
|---|---|
| Nome da Usina: | Usina Hipotética |
| CNPJ | 00.000.000/0000-00 |
| Responsável pelo preenchimento: | GT ACV RenovaCalc |
| Telefone : | (00) 0000-0000 |

Etanol Anidro

| | |
|---|---|
| Intensidade de Carbono (g $CO_2$eq/MJ) | 30,4 |
| Nota de Eficiência Energético-Ambiental (g $CO_2$eq/MJ) | 57,0 |

| | |
|---|---|
| agrícola | 28,1 |
| industrial | 1,0 |
| transporte | 0,8 |
| uso | 0,4 |

Fóssil de referência: Gasolina

87,4

Redução de emissões

65%

33

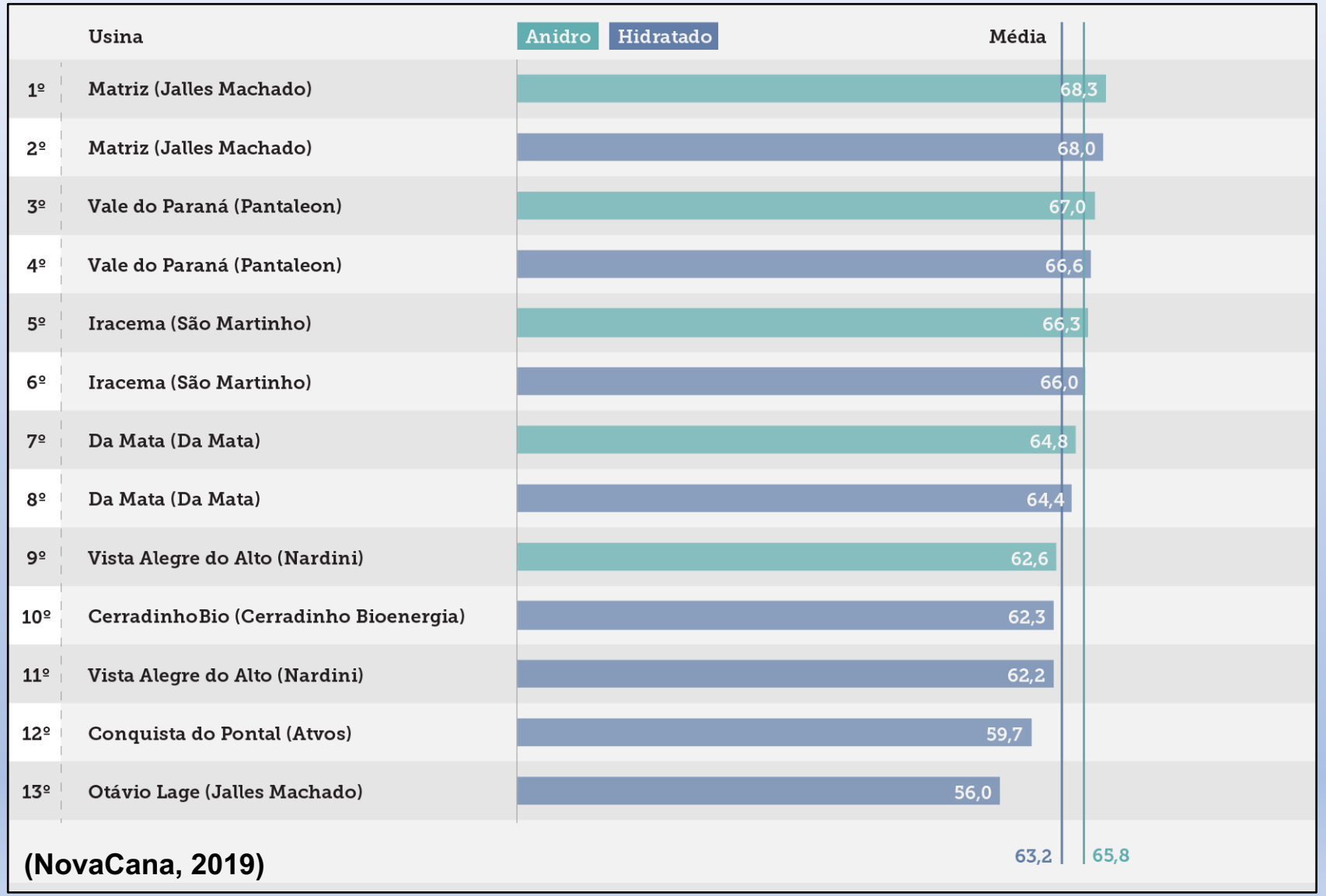
# *RenovaBio: recent figures and facts*

- ✓ ***RenovaBio implementation schedule is on time. Legislation has been put forward and stakeholders are taking positions. CBIO's trade was initiated in the Brazilian Stock Market in April/2020.***

- ✓ ***To date (April/2020), 10 certification firms have been accredited, including world class inspection firms, 93 producers are certified to issue CBIO's and 134 biofuel producers (ethanol, biodiesel and biogas) are in different stages of emission certification process, which take 1 to 3 months, depending on the complexity of unit, mainly in the feedstock supply. The certificate is valid for 4 years, subject to monitoring.***

- ✓ ***During the certification process, conservative default values can be adopted in Renovacalc. When using actual observed values, a public hearing should be done, exposing producer data on inputs, yield and productivity. Thus, an extensive and high quality database on LCA are becoming available.***

# RenovaBio: some values carbon mitigation efficiency




**(NovaCana, 2019)**

# *RenovaBio: economic aspects*

- ✓ ***Considering the GHG mitigation target for 2020, circa 29 million CBIO's should be traded.***
- ✓ ***CBIO value will be eventually defined by the market, but estimates indicate ranges from 5 to 10 USD/CBIO.***
- ✓ ***For the next decade is estimated a total demand of 591 million CBIO's, which could generate until 2028 a revenue up to 5.9 billion USD.***
- ✓ ***The impact on final price of fuels (at 10 USD/CBIO) was estimated: diesel: +0.3%, gasoline (E27): -0.01%, jet fuel: +0,7%, hydrous ethanol: -1%***
- ✓ ***Covid-19 affected fuel demand prospects, but the principles of RenovaBio were preserved.***

# *RenovaBio Program:*

## *fostering efficiency and sustainability*

- ✓ ***Science-based consistent evaluation of GHG emission and market-based valuation for carbon emission reduced risk perception and government intervention.***
- ✓ ***Intense dialog with stakeholders, transparent certification process and public consultation in relevant steps assured strong support to RenovaBio.***
- ✓ ***Careful planning, clear definition of mandates and good articulation among government agencies allowed schedule accomplishment, with regulatory orders issued and approved on time.***
- ✓ ***RenovaBio represents a driver for improvements in new and efficient bioenergy production capacity. It is expected a rise in ethanol production between 43 billion and 54 billion additional liters by 2030, from a production of about 27 million liters in 2018.***

*"Bioenergy represents a major type of renewable energy. As such, it is key to supporting the UN Sustainable Development Goals (SDGs) in the context of climate change and energy security."*

*"As summarized by the IPCC 5th Assessment Report, integrated assessment modelling indicates a high risk of failing to meet long-term climate targets without bioenergy. Global assessments by REN 21, IEA and IRENA find that bioenergy accounts for half of the most cost-effective options for doubling renewable energy use by 2030. "*

**Jeffrey Skeer**, Senior Programme Officer, IRENA

***Please, take home:***

***Biofuels can be very effective to reduce carbon emissions and improve air quality in cities. Now.***

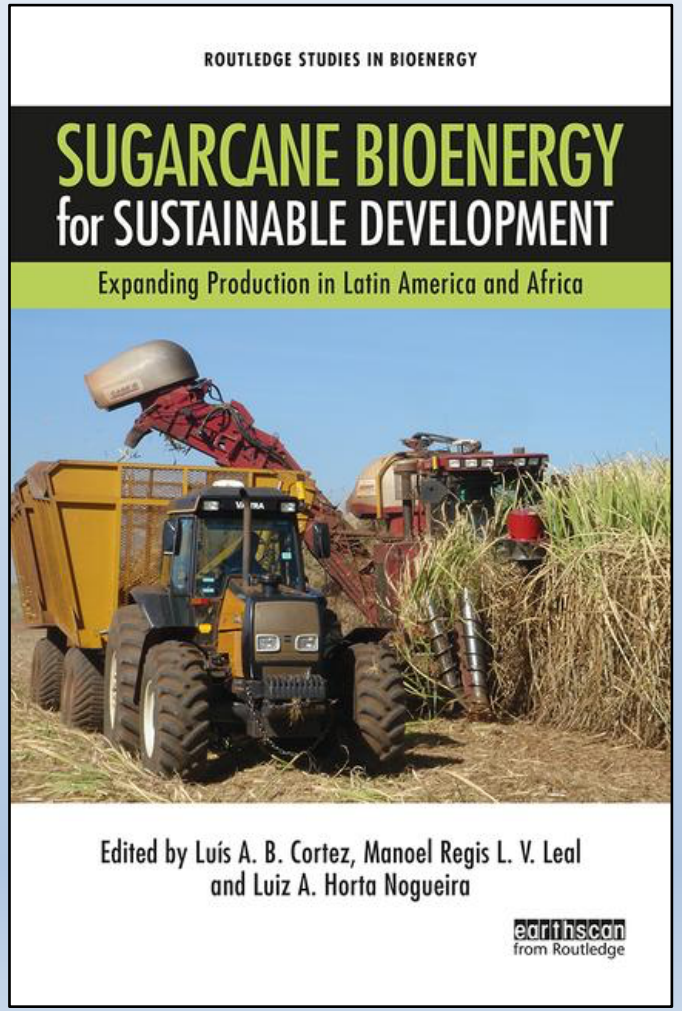
***Biofuels production and use are ready to be adopted in many developing countries.***

***Biofuels production potential are very large and its production brings relevant socioeconomic benefits. Immediately.***

# *Thanks for your attention.*


## *Luiz A. Horta Nogueira*

*NIPE/UNICAMP and EXCEN/UNIFEI*

# *For more information on sustainable bioenergy*

***A detailed assessment of global sustainable bioenergy potential and perspectives, the SCOPE (Scientific Committee on Problems of the Environment) report (2015), Bioenergy and Sustainability: bridging the gaps, prepared by 137 experts from 24 countries.***

***In this study is indicated that bioenergy properly implemented can help to:***

- ✓ ***increase resilience in food supply***
- ✓ ***decrease pollution***
- ✓ ***preserve biodiversity***
- ✓ ***improve human health***
- ✓ ***rehabilitate degraded land***
- ✓ ***mitigate climate change***
- ✓ ***provide economic and business opportunities***

**Available at:**
**http://bioenfapesp.org/scopebioenergy/**