Programa de Pós-Graduação em Energia

PEN 5014

Biomassa como Fonte de Energia - Conversão e Utilização

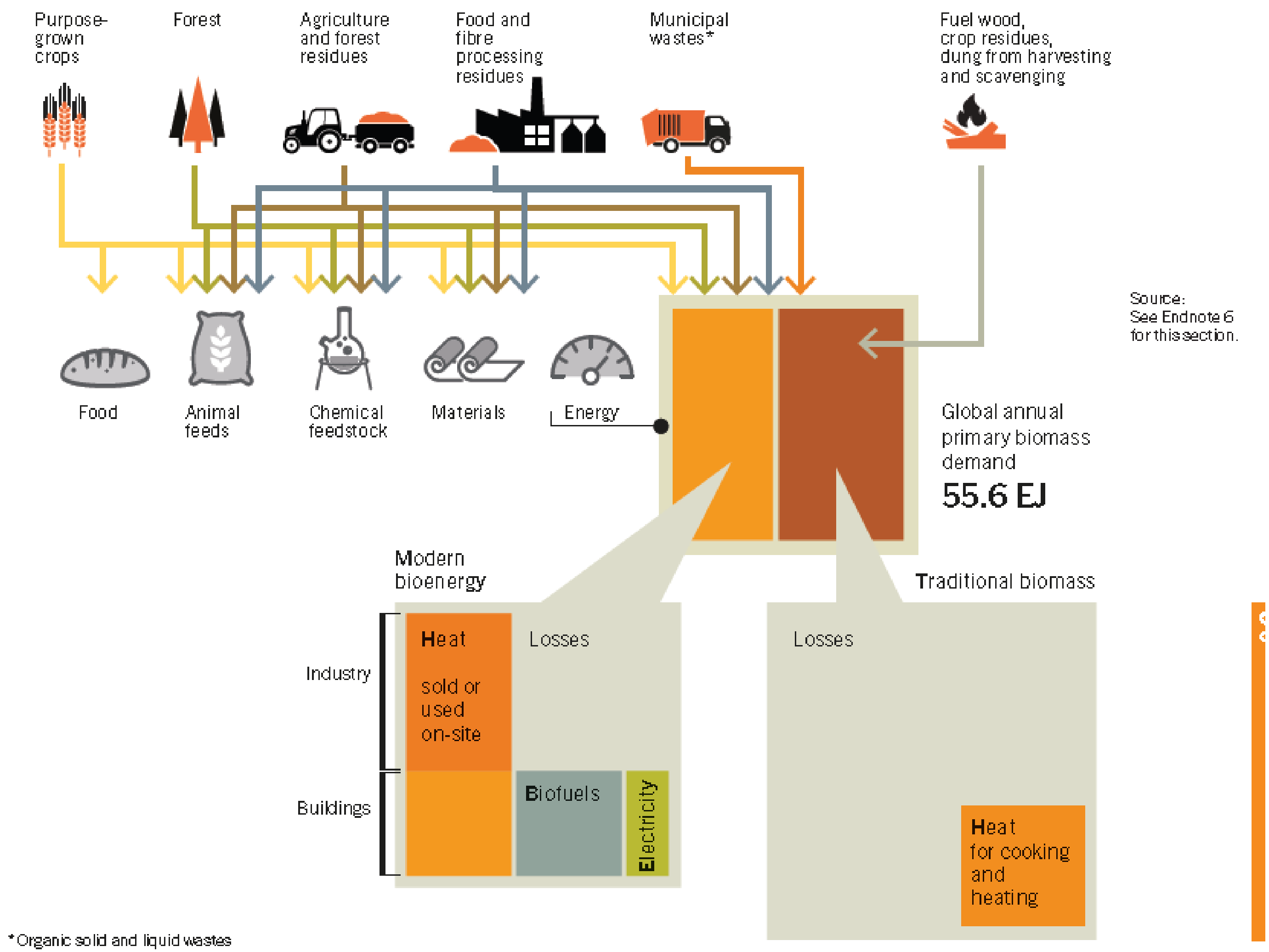
Biocombustíveis líquidos - ETANOL

Prof. Suani Coelho

São Paulo, 2 de outubro de 2020

Bioeconomy

Figure 5. Biomass Resources and Energy Pathways



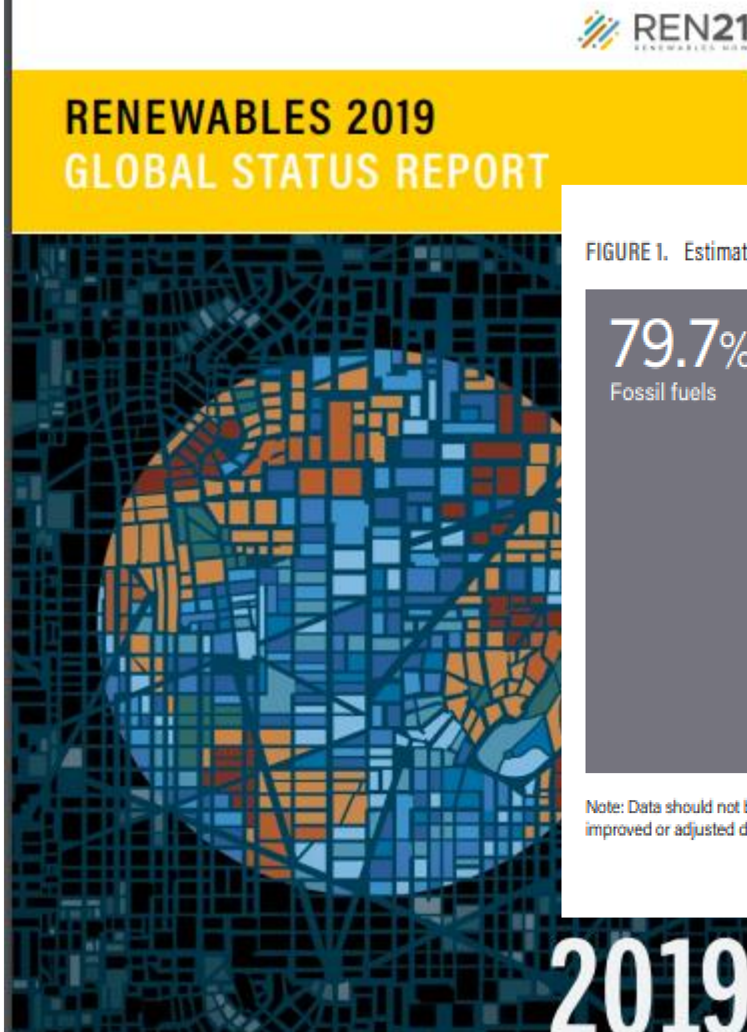
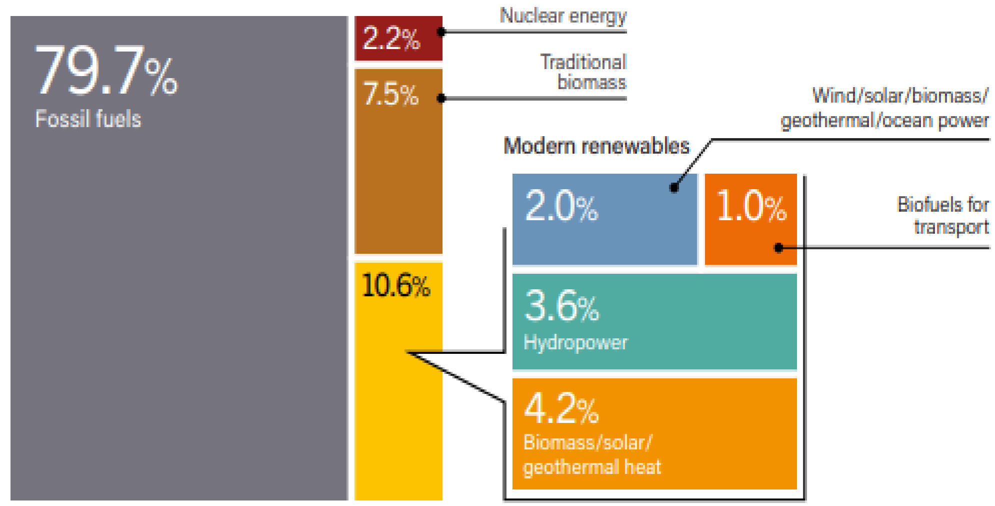


FIGURE 1. Estimated Renewable Share of Total Final Energy Consumption, 2017

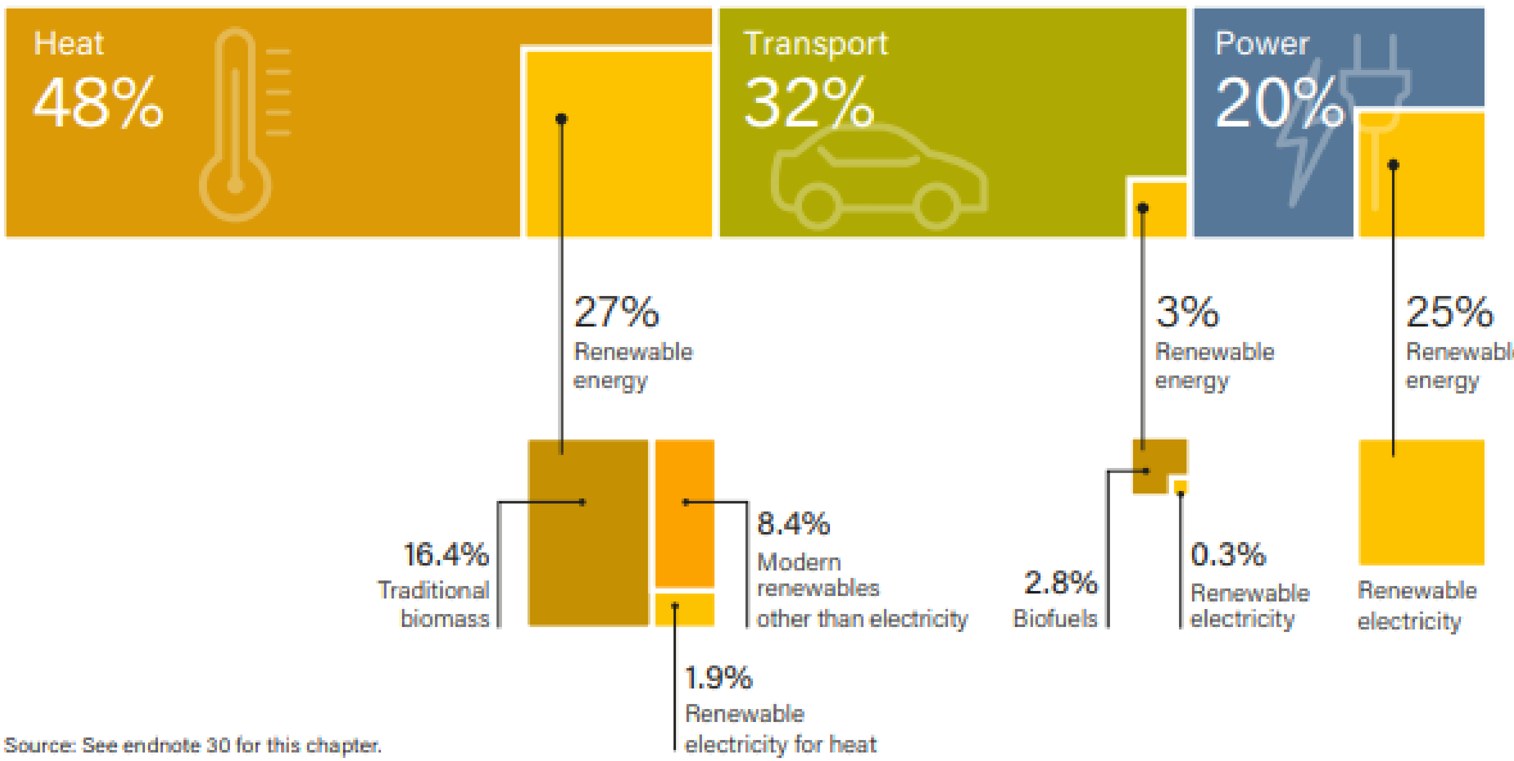


Note: Data should not be compared with previous years because of revisions due to improved or adjusted data or methodology. Totals may not add up due to rounding.

Source: Based on OECD/IEA and IEA SHC. See endnote 54 for this chapter.

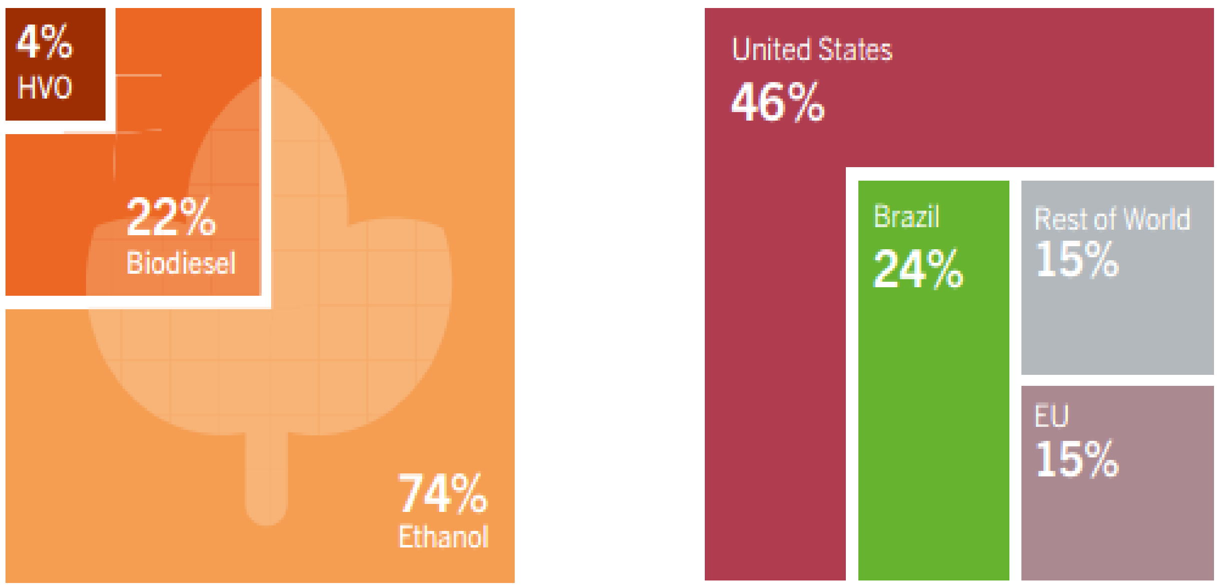
www.ren21.net

FIGURE 3. Renewable Energy in Total Final Energy Consumption, by Sector, 2015



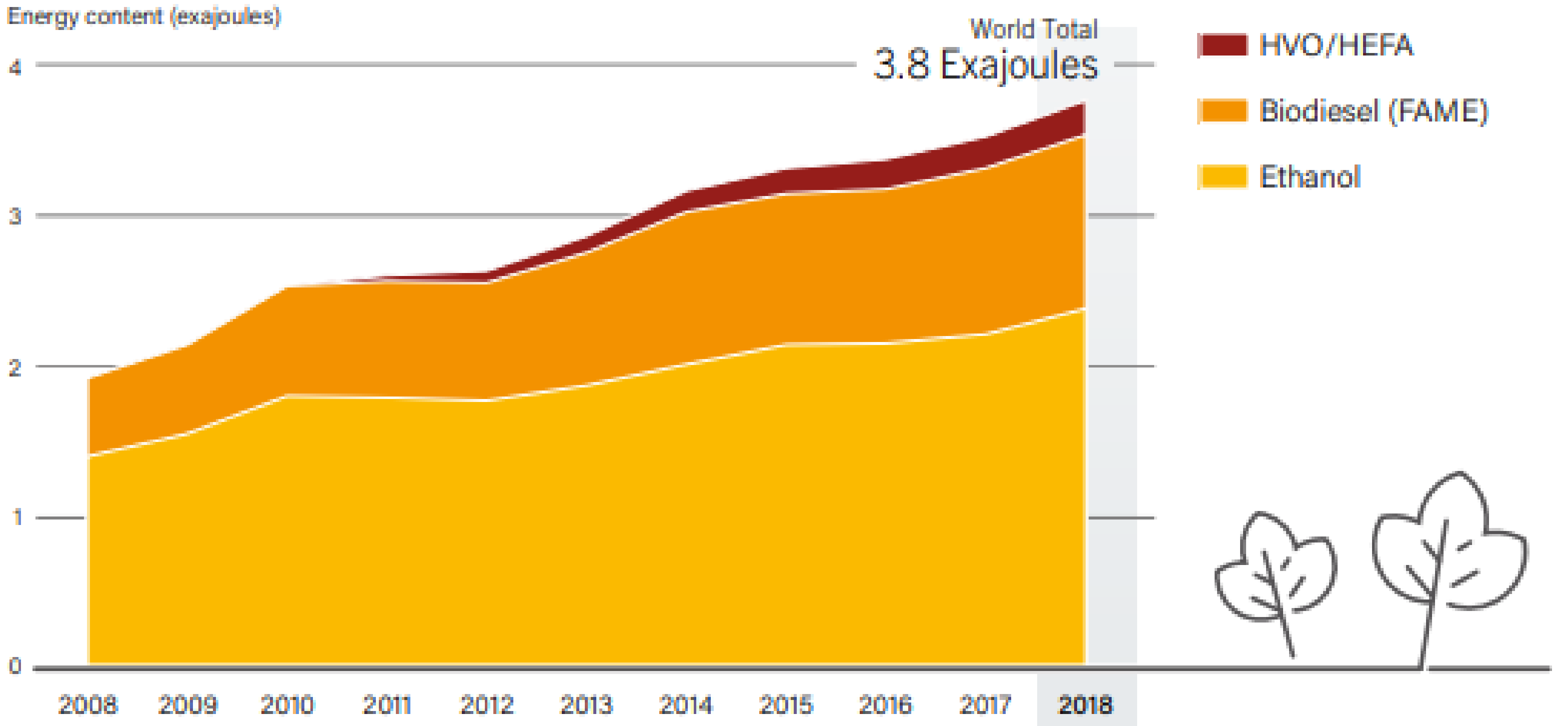
Source: See endnote 30 for this chapter.

Figure 9. Biofuels Global Production, Shares by Type and by Country/Region, 2015



Source:
See endnote 48
for this section.

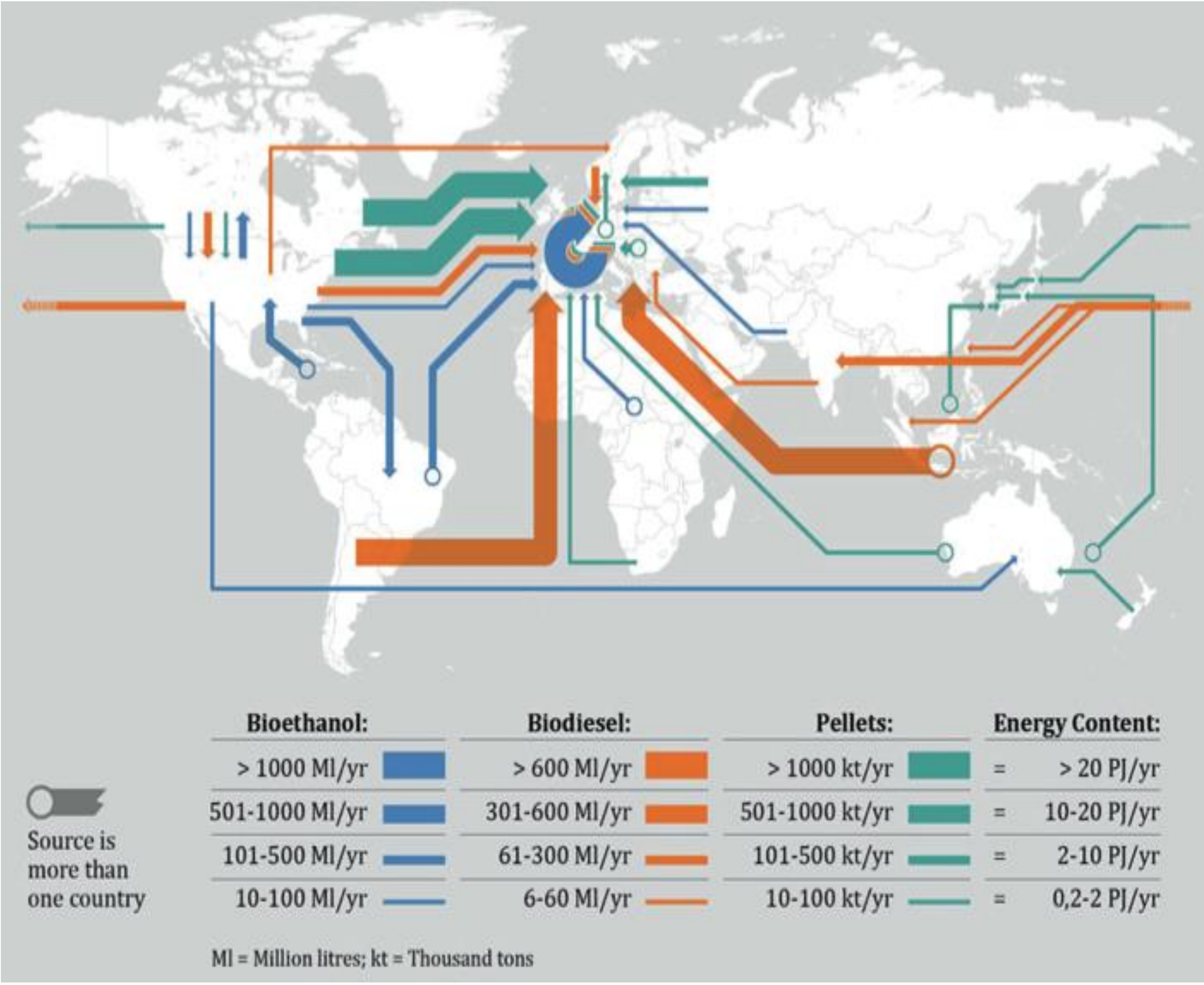
FIGURE 20. Global Ethanol, Biodiesel and HVO/HEFA Fuel Production by Energy Content, 2008-2018



Note: HVO = hydrotreated vegetable oil; HEFA = hydrotreated esters and fatty acids; FAME = fatty acid methyl esters

Source: See endnote 52 for this section.

Source: REN 21 Global Status Report (2019)



Source REN21.Renewables 2012 – Global Status Report

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Stakeholders:

EDITOR
Luís Augusto Barbosa Cortez

ROADMAP FOR SUSTAINABLE AVIATION BIOFUELS FOR BRAZIL

A Flightpath to Aviation Biofuels in Brazil

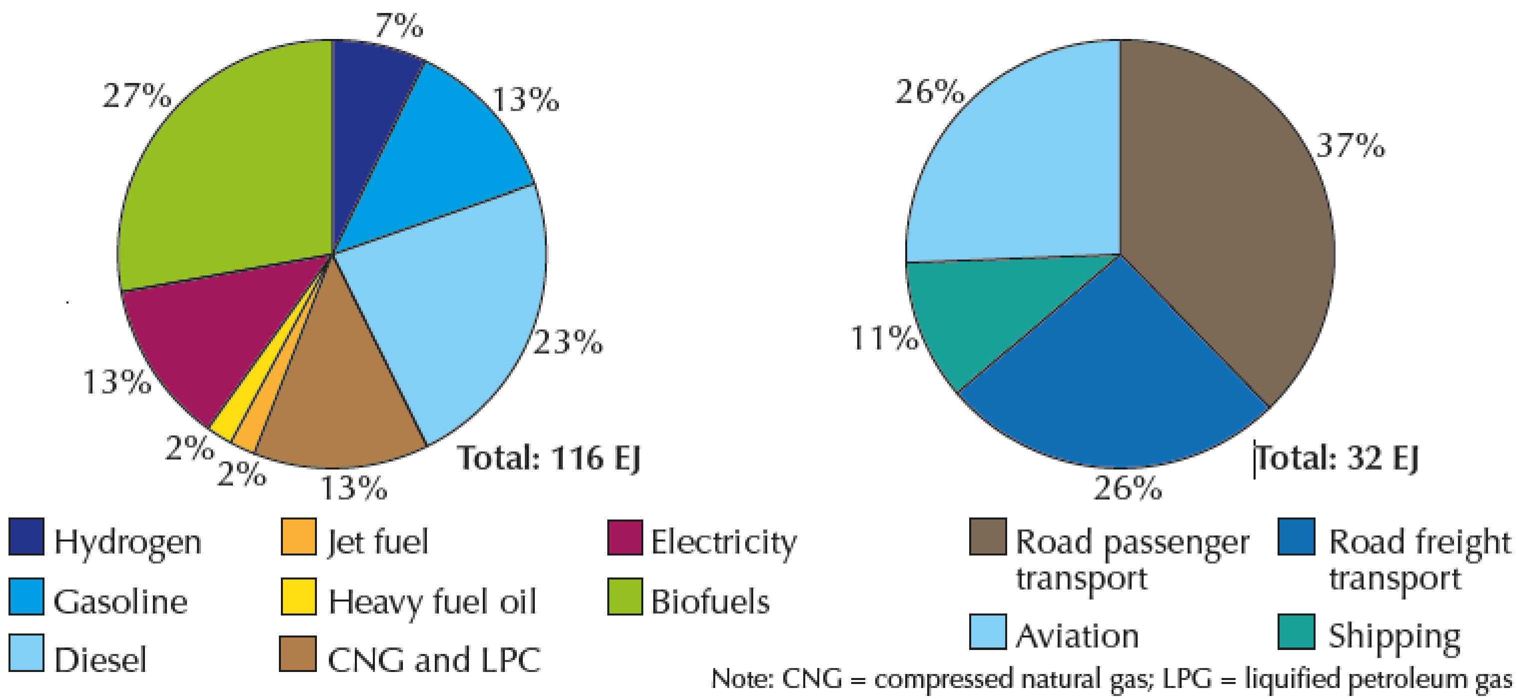

Figure 4 Global energy use in the transport sector (left) and use of biofuels in different transport modes (right) in 2050 (BLUE Map Scenario). Source: IEA, 2010.

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Table 1 Recent dtbelaemonstration flights using biomass derived jet fuel (ICAO, 2011).

DATE	AIRLINE	AIRCRAFT	ENGINE	PARTNER / FUEL SUPPLIER	SOURCE OF LIQUID JET FUEL BLEND
Feb 2008	Virgin Atlantic	B747-400	GE CF6-80C2	Imperium Renewables, Boeing	20% coconut and babassu
Dec 2008	Air New Zealand	B747-400	Rolls-Royce RB211-524G	UOP, Terasol, Boeing	50% jatropha
Jan 2009	Continental Airlines	B737-800	CFM International CFM56-7B	UOP, Terasol, Sapphire Energy, Boeing	47.5% jatropha, 2.5% algae
Jan 2009	Japan Airlines	B747-300	Pratt & Whitney JT9D-7R4G2	Nikki Universal/ UOP, Sustainable Oils, Boeing	42% camelina, 7.5% jatropha, 0.5% algae
Dec 2009	KLM	B747-400	GE	GE, Honeywell, UOP	50% camelina
Nov 2010	TAM Airlines	A320	CFM International	UOP	50% jatropha
Apr 2011	Interjet	A320	CFM International	CFM, Safran, EADS, Airbus, Honeywell, ASA	27% jatropha

Table 2 Commercial flights using biomass derived jet fuel (ICAO, 2012).

DATE/ROUTE	CARRIER	AIRCRAFT	FEEDSTOCK	NOTES
23 November 2009 Amsterdam - Paris	KLM	B747	Camelina	
29 June 2011 Amsterdam - Paris	KLM	B737	Used Cooking Oil	200 city pair flights from Sept. 2011
15 July 2011 Hamburg - Frankfurt	Lufthansa	A321	Jatropha, camelina, plants & animal fats	1,200 flights over six-month period
20 July 2011 Amsterdam - Helsinki	Finnair	A319	Jatropha	
21 July 2011 Mexico City - Tuxtila Gutierrez	Interjet	A320	Jatropha	
1 August 2011 Mexico City - Madrid	AeroMexico	B777	Jatropha	First biofuel transatlantic flight
3 October 2011 Madrid - Barcelona	Iberia	A320	Camelina	
6 October 2011 Birmingham - Arrecife	Thomson	B757	Used Cooking Oil	
13 October 2011 Toulouse - Paris	AirFrance	A321	Used Cooking Oil	Flight used 50% biofuel blend
27 September 2011 Mexico City to San Jose, Costa Rica	AeroMexico	Boeing 737-700	15% blend of camelina-derived jet biofuel	Weekly flights
7 November 2011 Houston to Chicago	United	B737-800	40% blend of biofuel made from algae	First USA biofuel commercial flight
9 November 2011 i) Seattle to Washington ii) Seattle to Portland	Alska Airlines	B737-800	20% biofuel blend made from cooking oil	First of 75 flights
22 December 2011 Bangkok to Chiang Mai	Thai	Boeing 777-200	Used Cooking Oil	
12 January 2012 Frankfurt to Washington DC	Lufthansa	Boeing 747	Biosynthetic fuel	
7 March 2012 Santiago to Conception	Lan	Airbus A320	Used vegetable oil	
13 April 2012 Sydney to Adelaide	Qantas	Airbus A330	Used Cooking Oil	Australia's first commercial biofuel flight
17 April 2012 Toronto to Ottawa	Porter	Bombardier Q400	Camelina sativa and Brassica carinata	

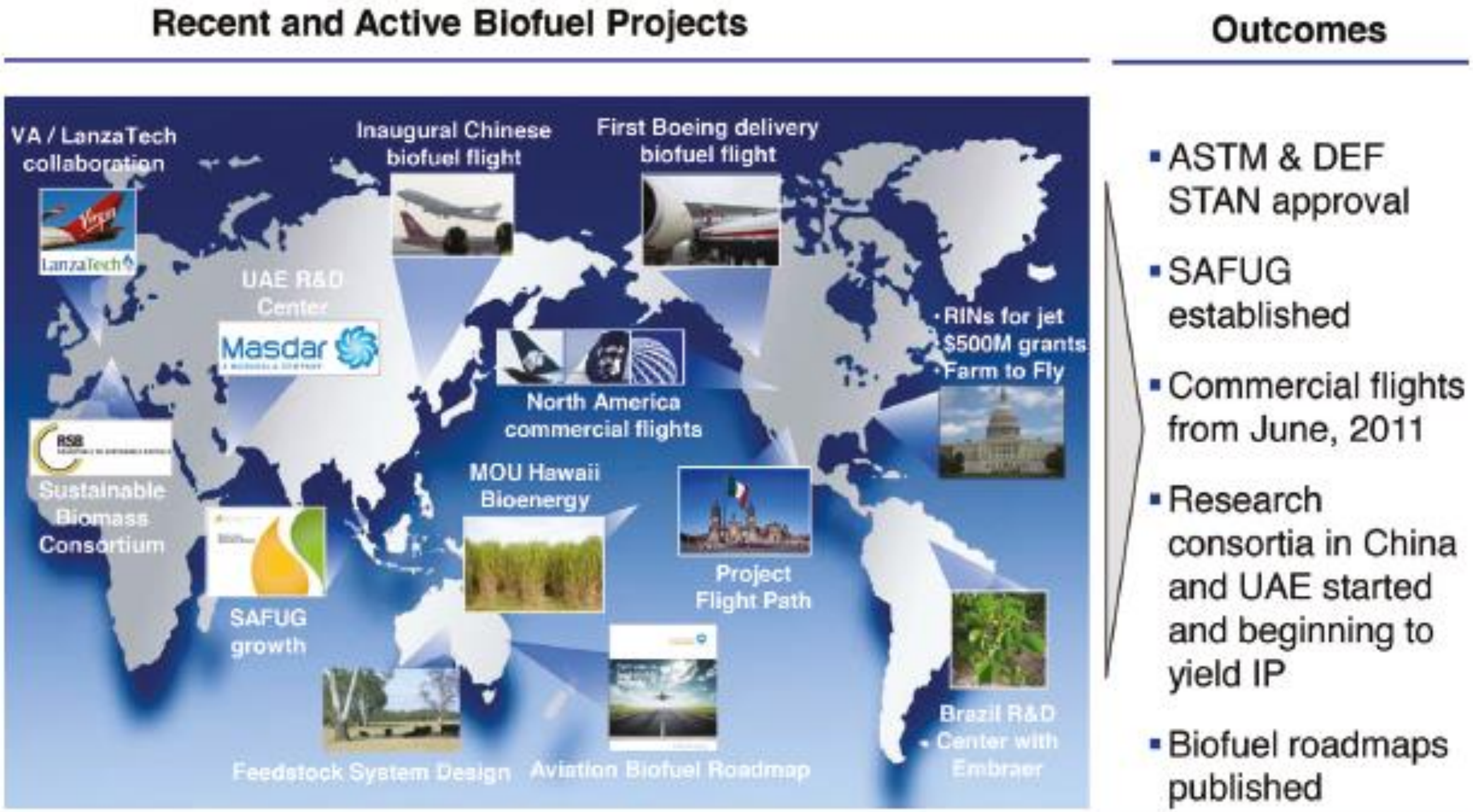


Figure 23 Boeing global biofuel engagements. Source: Boeing apud Lyons, 2012.

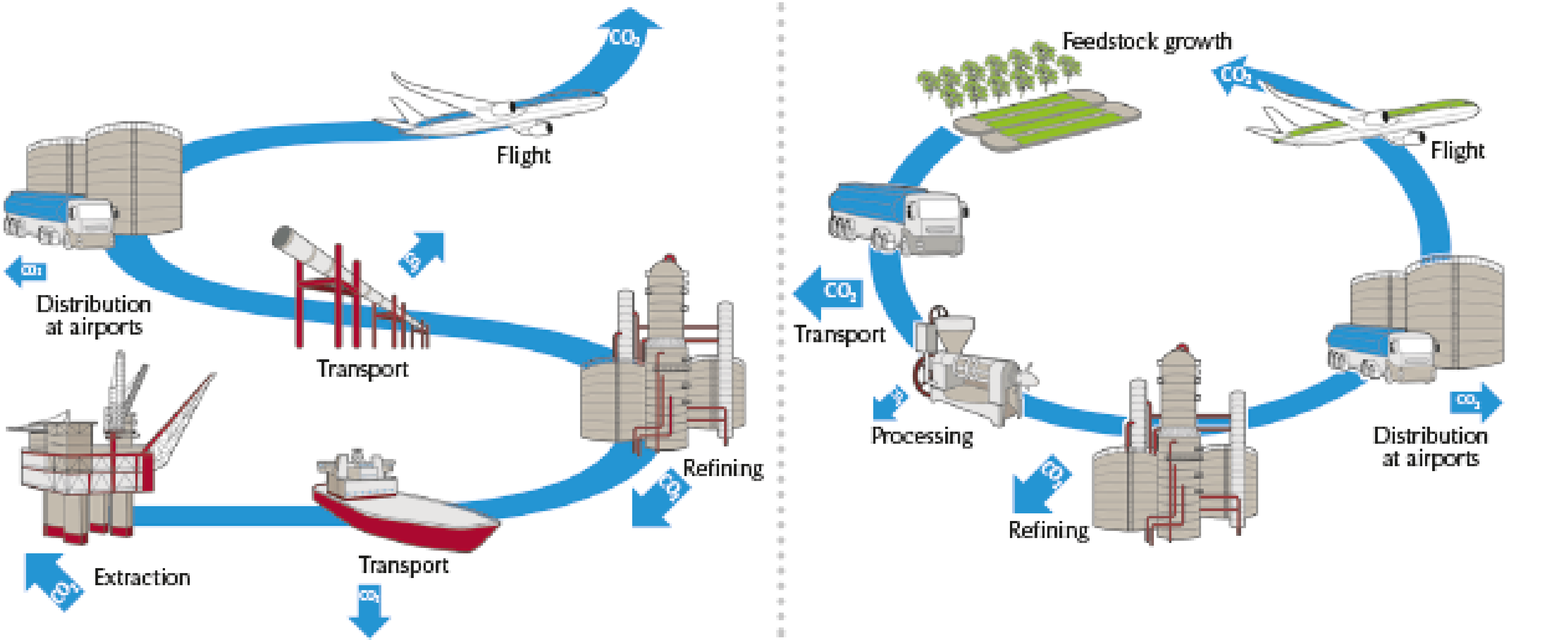
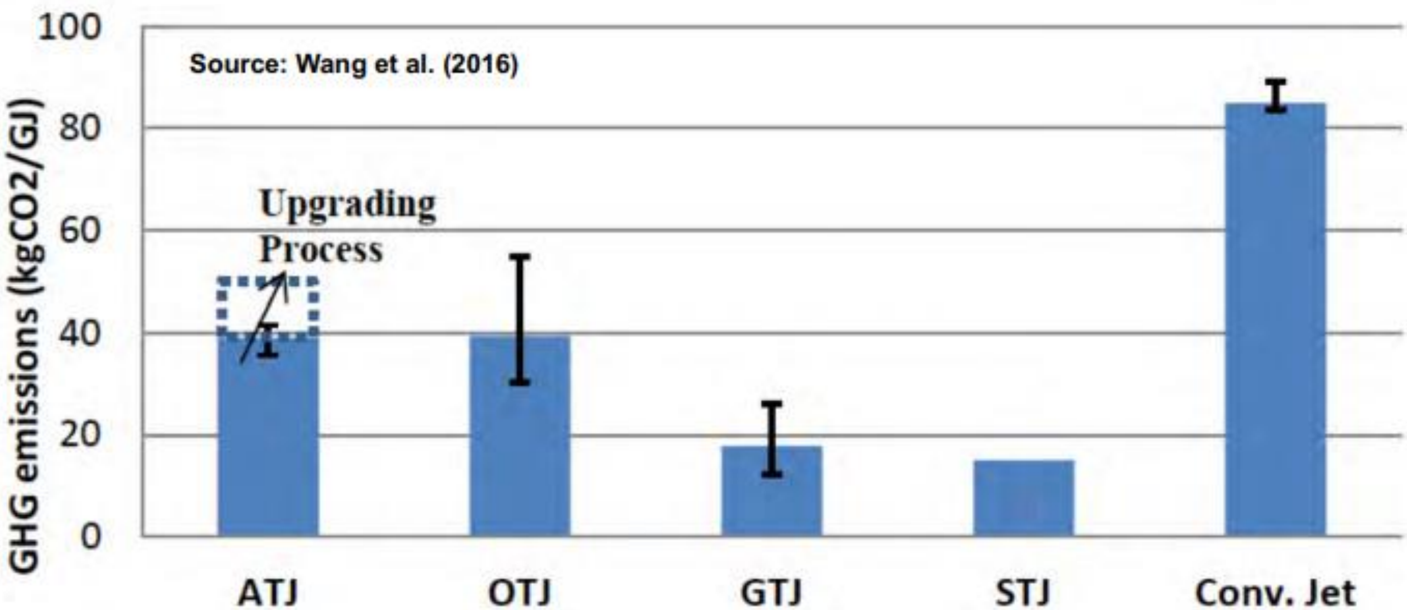


Figure 11 Comparative Life Cycle Analysis (LCA) for CO_2 emissions using kerosene (left) and biofuels (right). Source: ATAG, 2011.

Findings of Life Cycle Analyses (LCA) For Jet Fuel Pathways

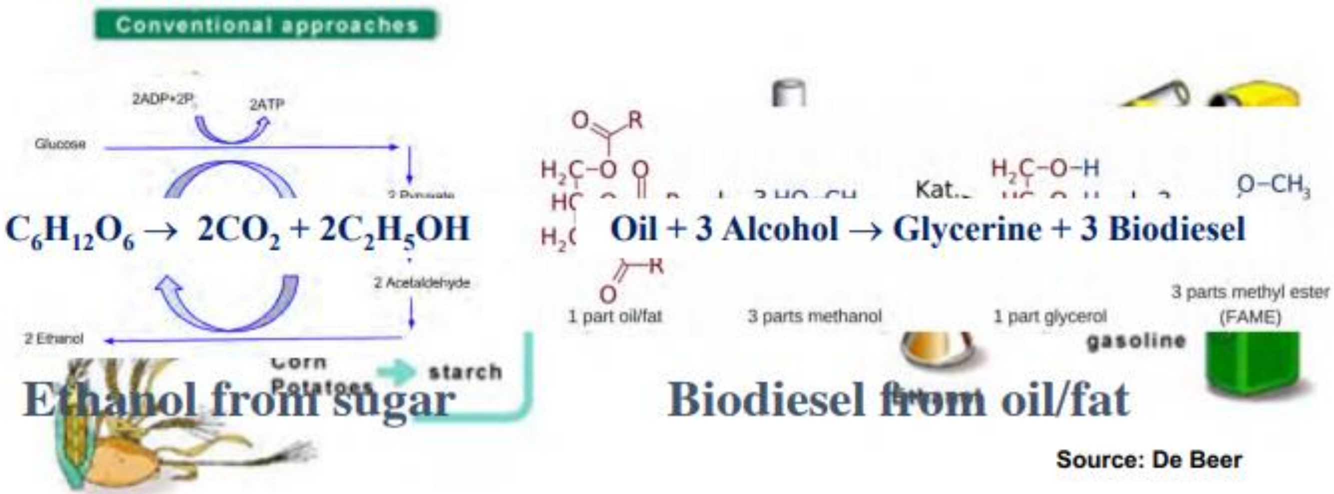


ATJ: Alcohol-to-jet fuel
OTJ: Oil-to-jet fuel
GTJ: Gas-to-jet fuel
STJ: Sugar-to-jet fuel
Conv.Jet: Conventional

Biofuels

1st, 2nd, 3rd, and 4th Generation Biofuels

<u>1st Generation</u> (conventional biofuels): Produced from food crops grown on arable land. Vegetable oil or sugar/starch converted into biodiesel or ethanol, using transesterification or yeast fermentation. Criticized for marginal environmental benefits and for placing fuel in competition with food.



$$C_6H_{12}O_6 \rightarrow 2CO_2 + 2C_2H_5OH$$

$$\text{Oil} + 3\ \text{Alcohol} \rightarrow \text{Glycerine} + 3\ \text{Biodiesel}$$

Ethanol from sugar **Biodiesel from oil/fat**

Source: De Beer

Biofuels

1st, 2nd, 3rd, and 4th Generation Biofuels

2nd Generation: Produced from lignocellulosic biomass, agricultural residues or waste plant material, grown on lands not targeted for cultivating food, not consuming large amounts of water or fertilizer.

Examples of Feedstocks

- **Energy crops**
- **Agricultural residues/green wastes**
- **MSW**
- **Black liquor**

Examples of Conversion Processes

- **Syngas catalysis**
- **Syngas-to-liquid (Fischer–Tropsch)**
- **Biocatalysis**
- **Hydro thermal upgrading**

Biofuels

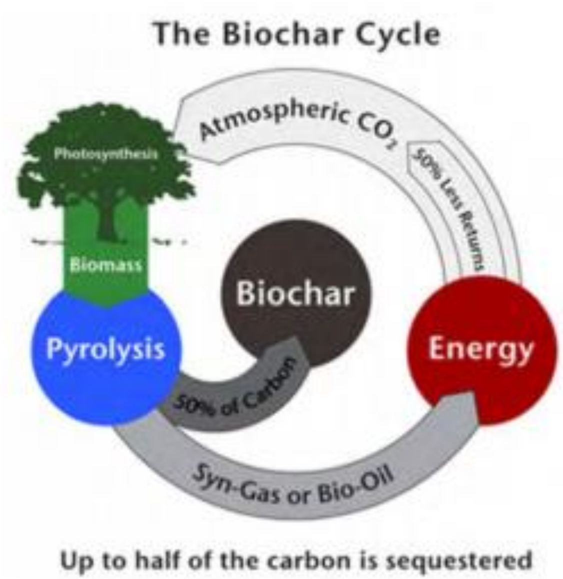
1st, 2nd, 3rd, and 4th Generation Biofuels

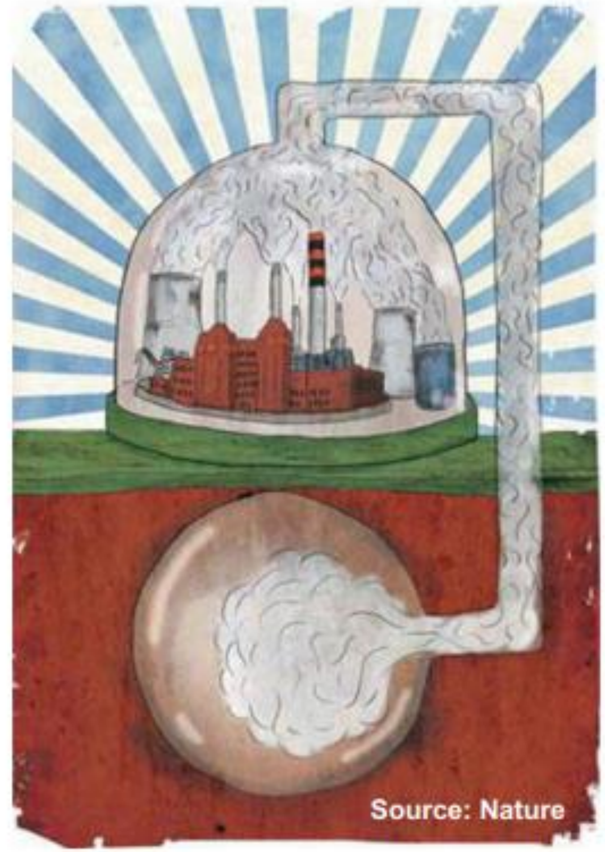
<u>3rd Generation</u>: Uses specially engineered energy crops such as algae. Algaculture – unlike crop-based biofuels – does not compete with food production, requiring neither farmland nor fresh water.

Biofuels

1st, 2nd, 3rd, and 4th Generation Biofuels

4th Generation: Produces sustainable energy while sequestering CO_2; carbon negative rather than carbon neutral.





CHALLENGES FOR BECCS IMPLEMENTATION THROUGH A SOCIO-TECHNICAL APPROACH[1]

Mascarenhas, Karen L.[1,2,3]; Coelho, Suani T.[1,3]; Meneghini, Julio R.[1,3]
[1]Research Centre for Gas Innovation, University of São Paulo; [2]Imperial College London
[3]University of São Paulo, São Paulo, Brazil

ABSTRACT: Some of the great contemporaneous challenges in the world involves dealing with energy, food production and supply, at the same time, reducing greenhouse gas emissions and their impact on climate change. As so, aiming to reduce carbon concentrations in the atmosphere, many studies recommend the inclusion of technologies as Carbon Capture and Storage (CCS) or Carbon Capture Usage and Storage (CCUS) to follow through energy transition to lower carbon concentration. As discussed in this paper and other publications by one of the authors (STC), only fossil fuel replacement is not enough to achieve a temperature increase of up to 2° C. Therefore, bioenergy, together with these technologies, named Bioenergy Carbon Capture and Storage (BECCS) or Bioenergy Carbon Capture Usage and Storage (BECCUS), has the potential to reach negative emissions on bioenergy life cycle. Consequently, understanding the challenges for the implementation of such technologies requires a broad perspective that is addressed through a socio-technical approach. In fact, BECCUS can be an option to contribute to these goals, putting together both bioenergy and CCS / CCUS as discussed in previous publication. BECCUS is already becoming a reality in Brazil, since several sugarcane ethanol mills already sell CO_2 from their fermentation process to other industries. However, there are still (technical, economic, social and environmental) challenges mainly related to BECCS, not yet implemented in the country. Therefore, this is the main objective of this paper: to analyse the challenges for BECCS in the country in a socio-technical approach.

Keywords: technology, social aspects, sustainability, sugarcane, CO_2 emission, CO_2 reduction.

EUBCE 2020 (European Biomass Conference) – Disponivel no e-disciplinas

Biocombustíveis líquidos no Brasil
- Etanol
- Biodiesel

http://www.epe.gov.br/sites-pt/publicacoes-dados-abertos/publicacoes/PublicacoesArquivos/publicacao-377/topico-470/Relat%C3%B3rio%20S%C3%ADntese%20BEN%202019%20Ano%20Base%202018.pdf

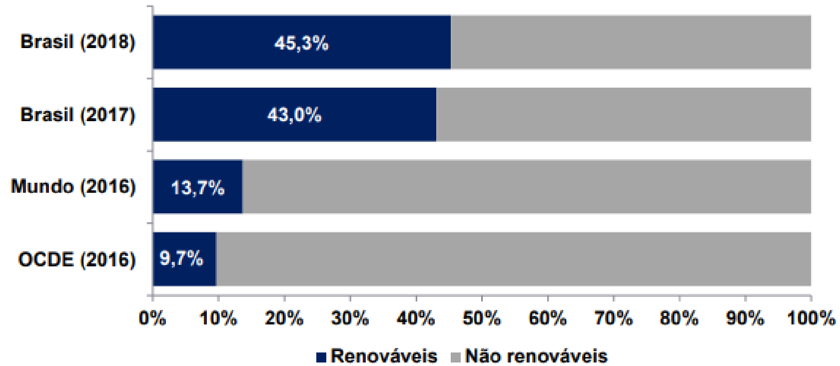
Matriz energética

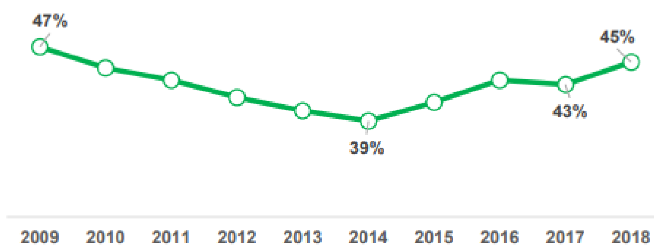
http://www.epe.gov.br/sites-pt/publicacoes-dados-abertos/publicacoes/PublicacoesArquivos/publicacao-377/topico-470/Relat%C3%B3rio%20S%C3%ADntese%20BEN%202019%20Ano%20Base%202018.pdf

Matriz energética

BEN 2019 | Participação de renováveis na matriz energética[1]

- ✓ Incremento da geração hidráulica e eólica;
- ✓ Aumento da oferta de lixívia e biodiesel;
- ✓ Redução da oferta de petróleo e derivados;
- ✓ Redução da oferta de gás natural.





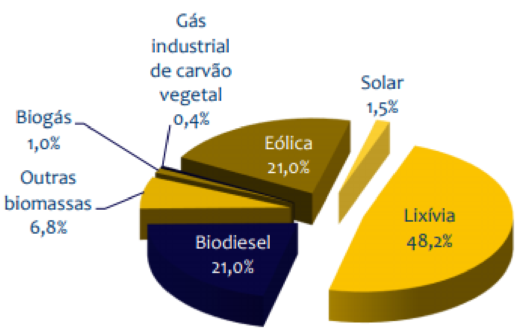
[1] A renovabilidade é calculada com base na Oferta Interna de Energia - OIE.

Fonte: EPE; Agência Internacional de Energia. Elaboração: EPE

Matriz energética

BEN 2019 | Repartição de 'lixívia e outras renováveis'

Lixívia e outras renováveis 6,9%



Biodiesel ultrapassa Eólica

Lixívia e outras renováveis (mil tep)	2017	2018	△ 18 / 17
Lixívia	8.892	9.553	7,4%
Biodiesel	3.313	4.174	26,0%
Outras biomassas[1]	1.280	1.351	5,5%
Biogás	191	204	6,7%
Gás industrial de carvão vegetal	74	88	18,7%
Eólica	3.644	4.169	14,4%
Solar	72	298	316,2%
Total	17.467	19.837	13,6%

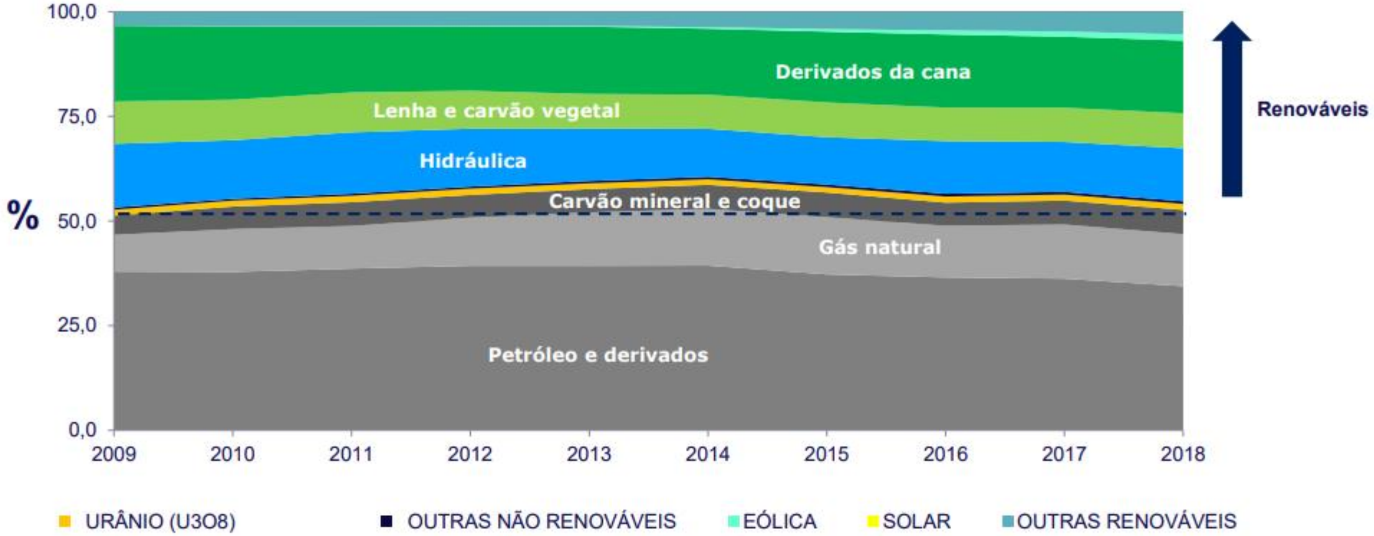
[1] Inclui casca de arroz, capim-elefante e óleos vegetais

Matriz energética

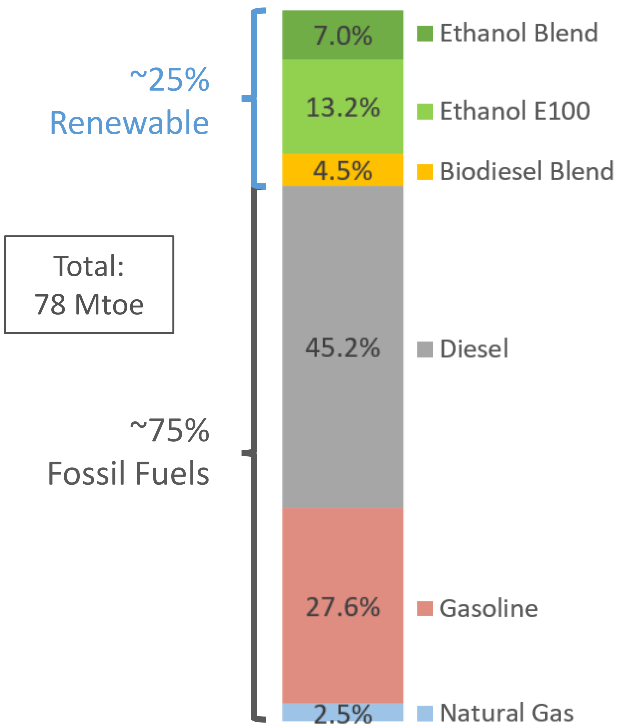
BEN 2019 | Oferta interna de energia 2009 - 2018

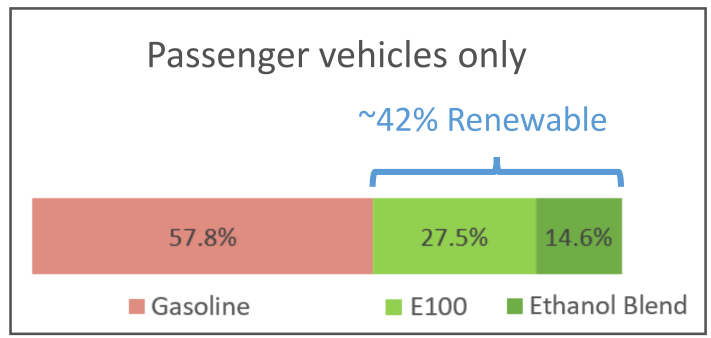
Mil tep

2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
243.070	268.706	272.250	283.321	296.422	305.635	299.672	288.395	293.268	288.392



Scale of biofuels in Brazil: Road transport fuel mix





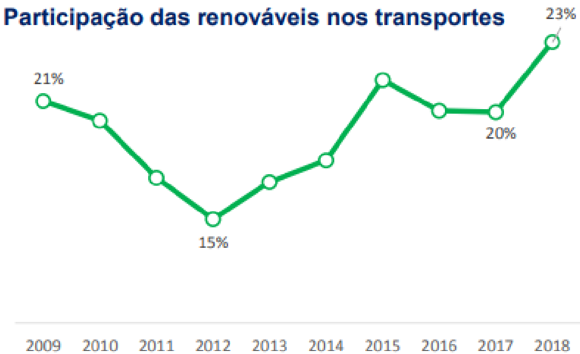
Road transport energy supply
Source: data from EPE (2019) – Year 2018

Setor de transportes

BEN 2019 | Consumo de energia nos transportes - matriz

2018	83,7 Mtep
2017	84,3 Mtep
	-0,8%

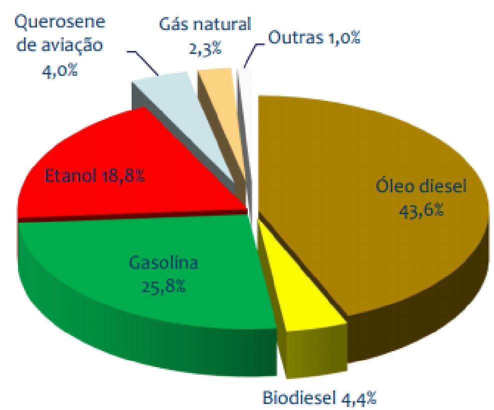
Participação das renováveis nos transportes



- Etanol +13,5%
- Gasolina -13,1%

} Produtos substitutos

- Óleo diesel -1,1;
- Biodiesel +2,7% (aumento do percentual na mistura – B10)



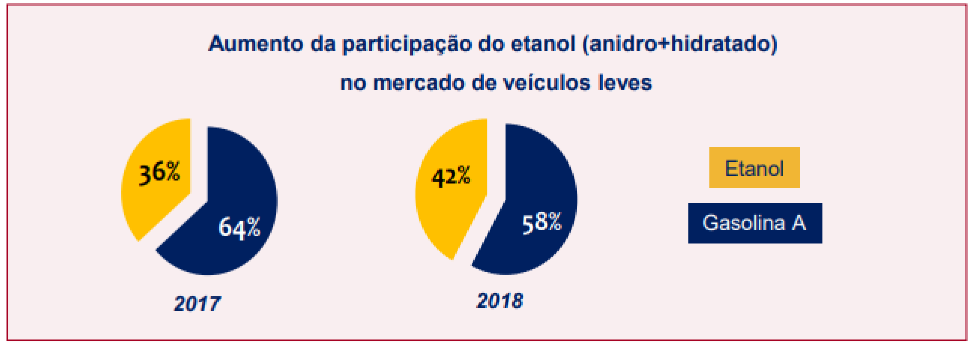
Setor de transportes

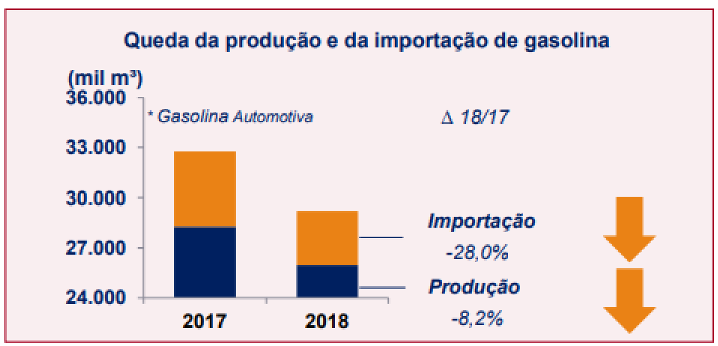
BEN 2019 | Consumo de energia nos transportes - destaques

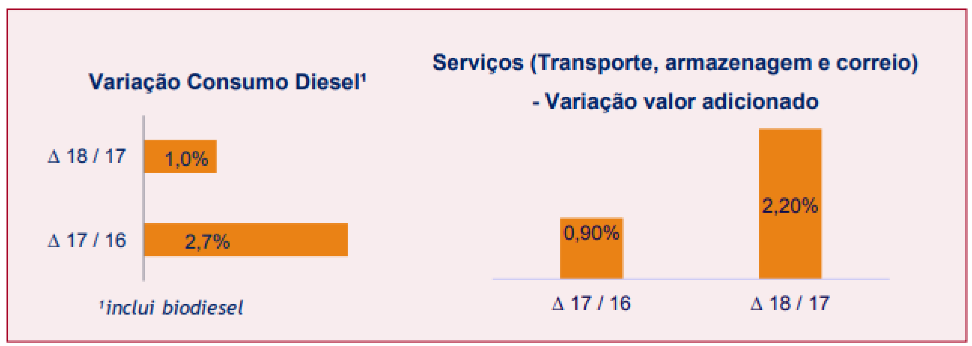
Etanol hidratado 38,6%

Gasolina automotiva -13,1%

variação % 2018/2017







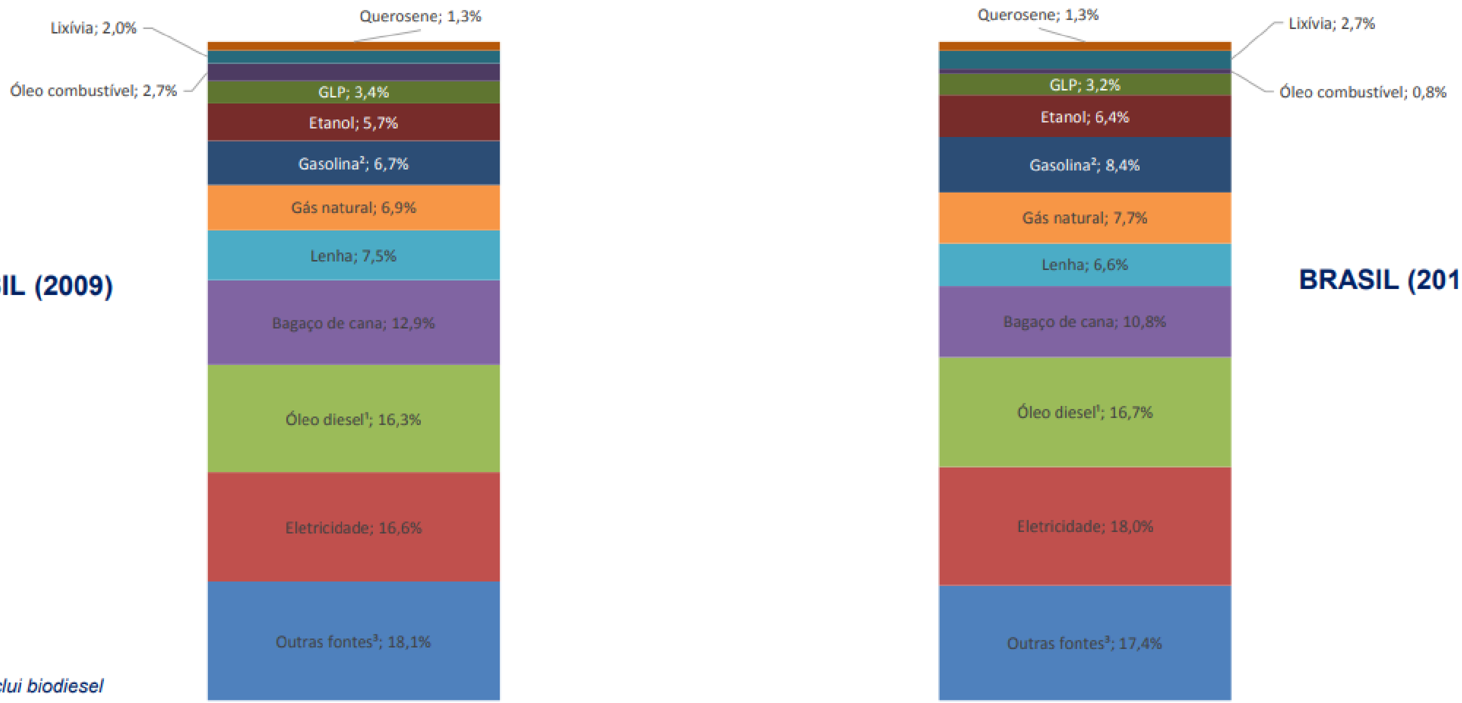
Fonte: EPE; IBGE. Elaboração: EPE

Biocombustiveis na matriz energética brasileira

BEN 2019 | Consumo final de energia por fonte - participação

BRASIL (2009)

BRASIL (2018)



[1] Inclui biodiesel

[2] Inclui gasolina de aviação

[3] Inclui gás de refinaria, coque de carvão mineral , de carvão vegetal e de petróleo, alcatrão, nafta, carvão mineral, outros energéticos de petróleo, asfalto, lubrificante s e solventes.

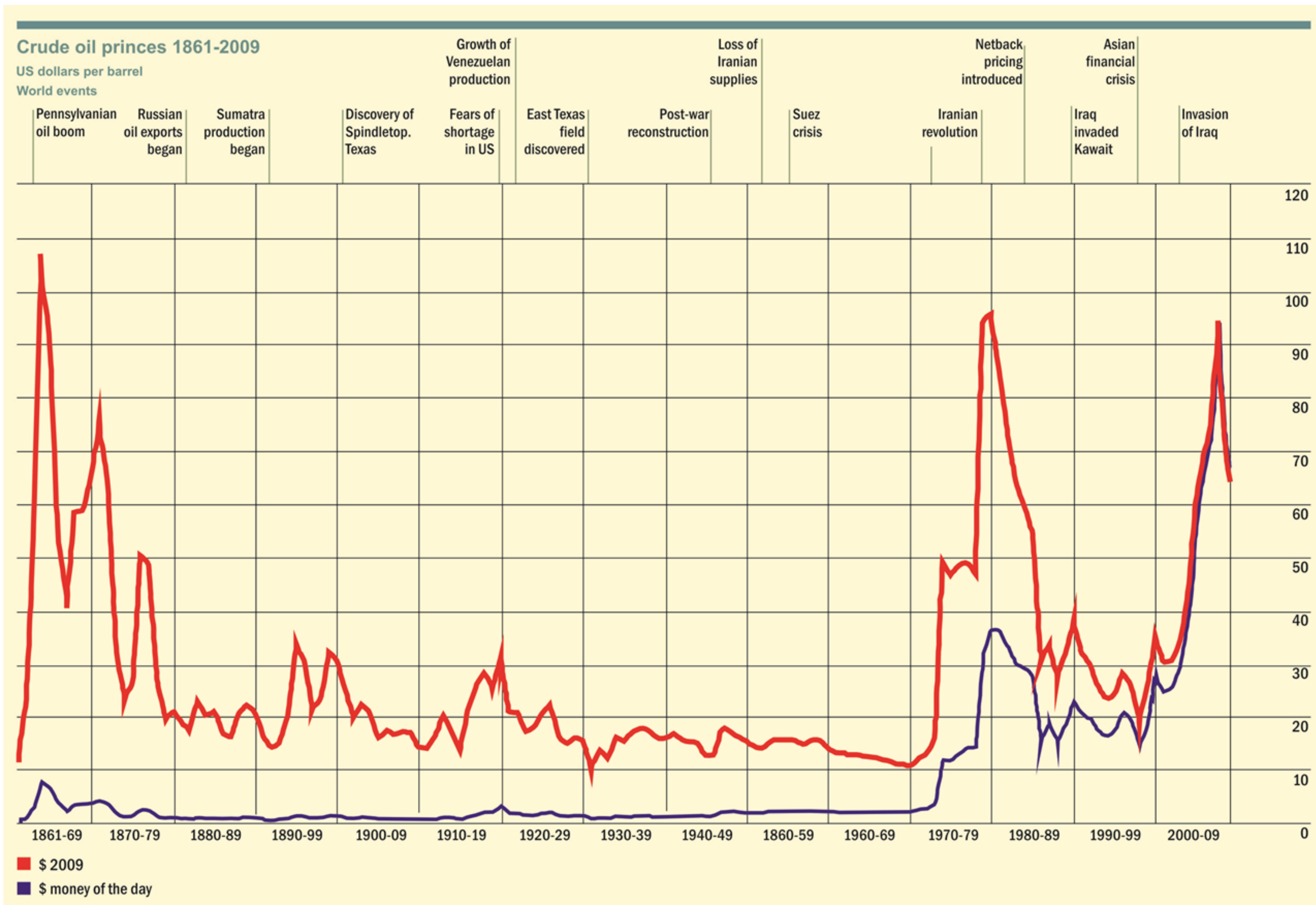
O Programa Brasileiro do Álcool

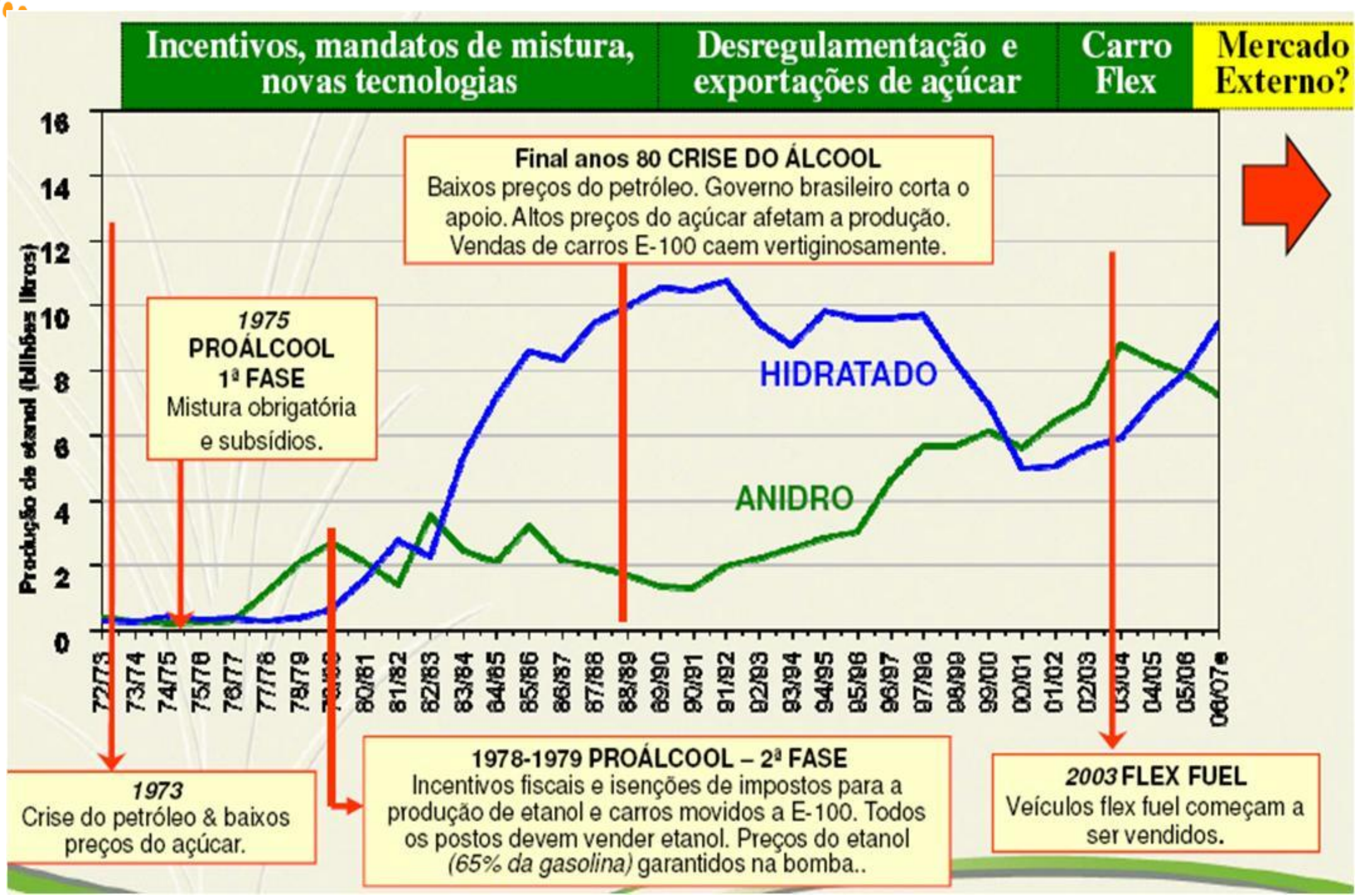
- Foi o maior programa comercial de biomassa. Hoje em segundo lugar...
- Iniciado pelo Governo Federal em 1975.
- Decisão do Governo Federal de produzir etanol e açúcar (de cana-de-açúcar): objetivo de reduzir as importações de petróleo.
- Combustível de alta octanagem, substituiu chumbo e MTBE.
- 2003 - Veículos bi-combustível - flex
- Etanol (anidro) adicionado a

  toda gasolina: 20 a 27% de etanol (em volume) – gasohol (HOJE 27%)
- Atualmente – deve ser economicamente competitivo com a gasolina
- RENOVABIO

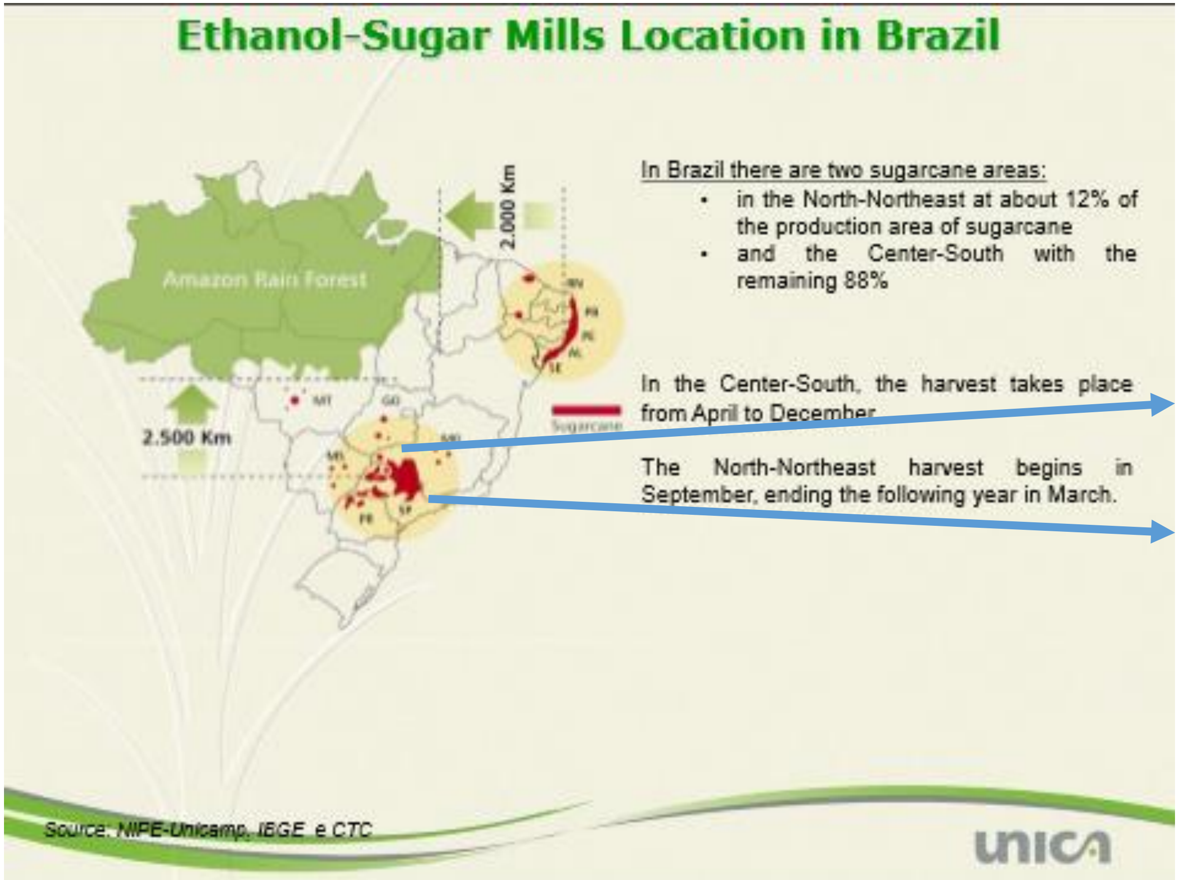
Preços históricos de petróleo

Goldemberg, 2011





Source: Datagro, Icone e UNICA



2019/2020
Sugarcane season

642.7 MM t cane

Center-South:
590.4 **MM t cane**

Sao Paulo State
343.7 MM t cane

Próxima aula: séries históricas de produção de cana, açúcar e álcool no Brasil, NE, Centro-Sul e SP
Gráficos e discussão

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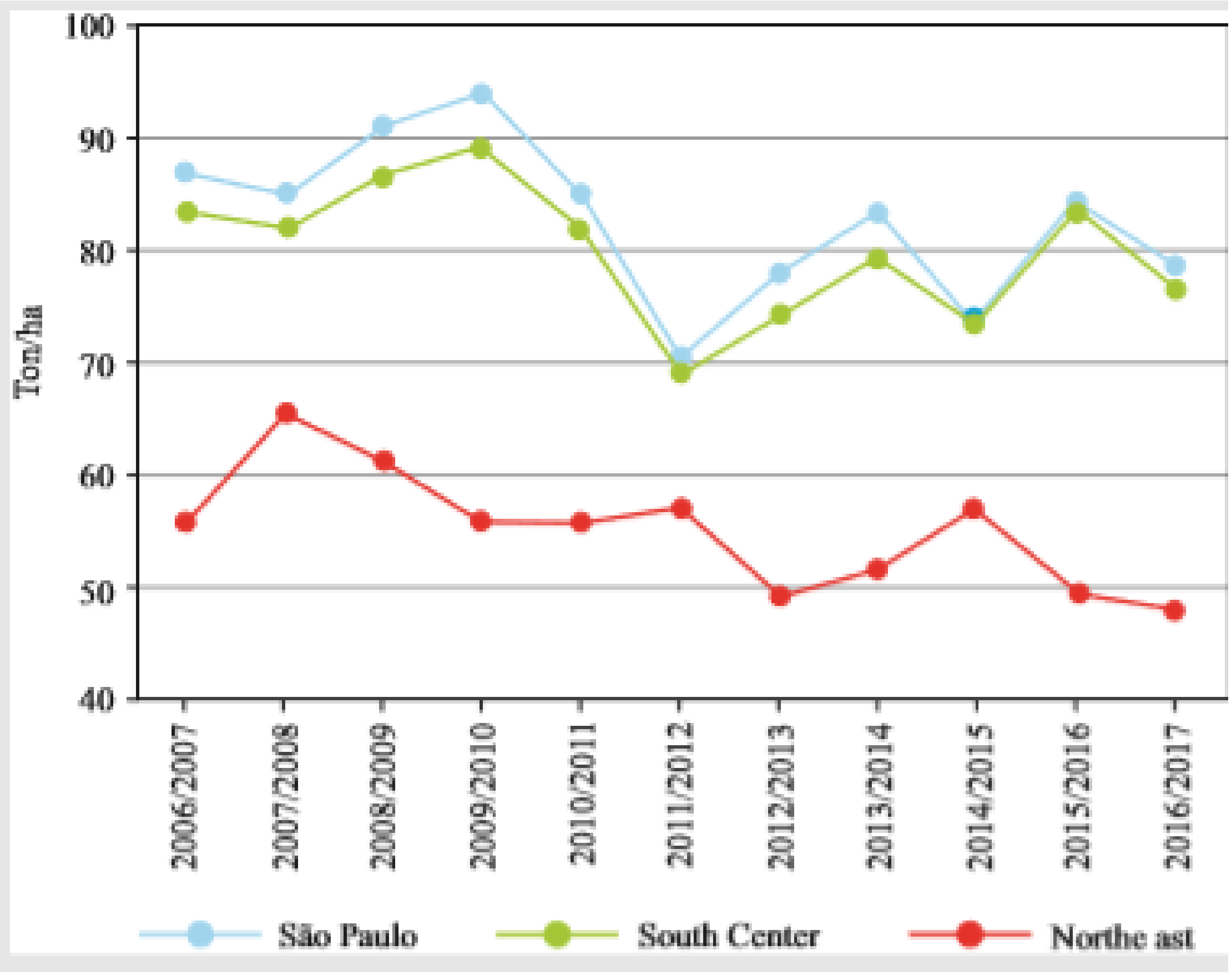
Produtividade agrícola de cana no Brasil



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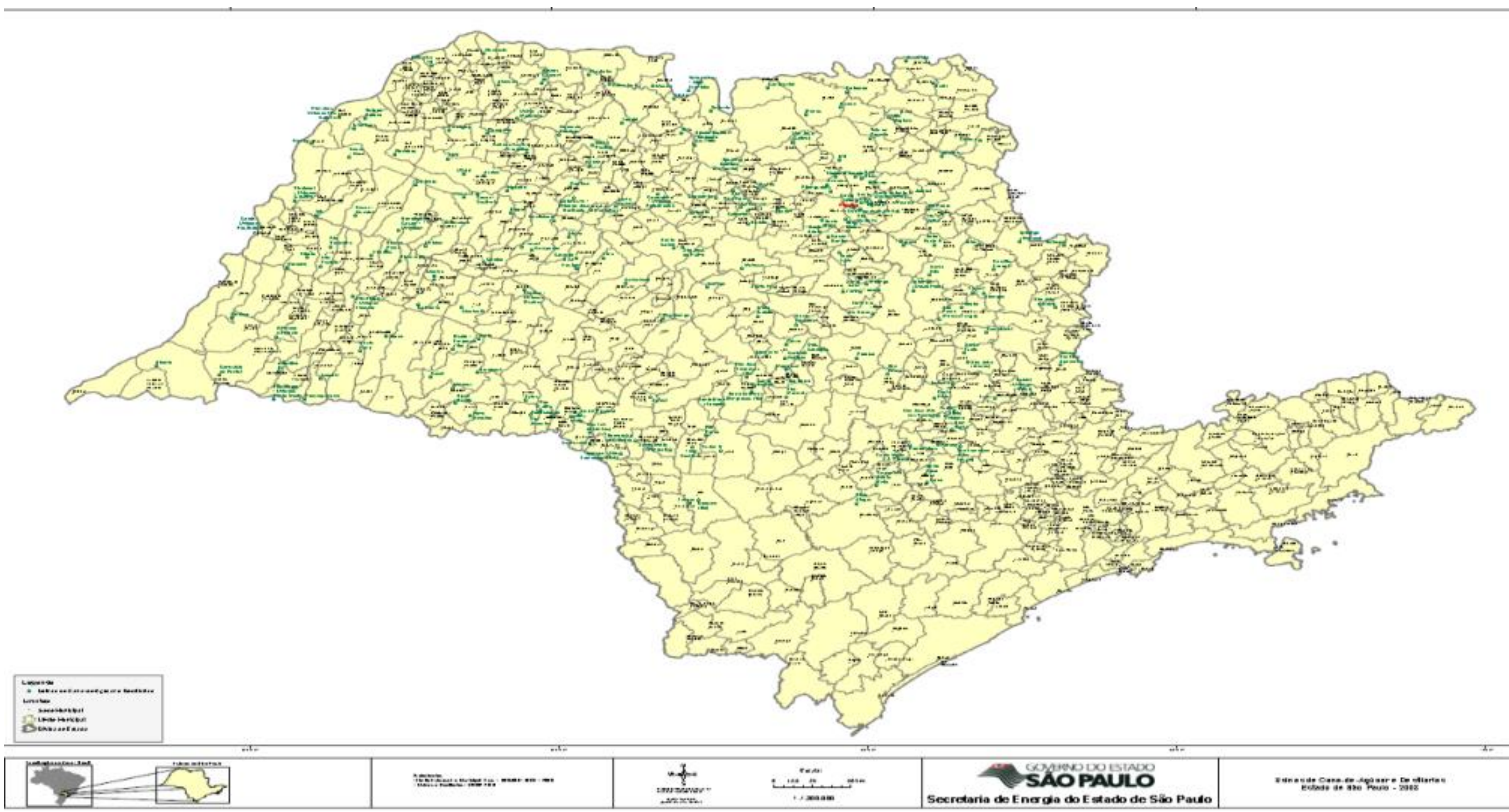
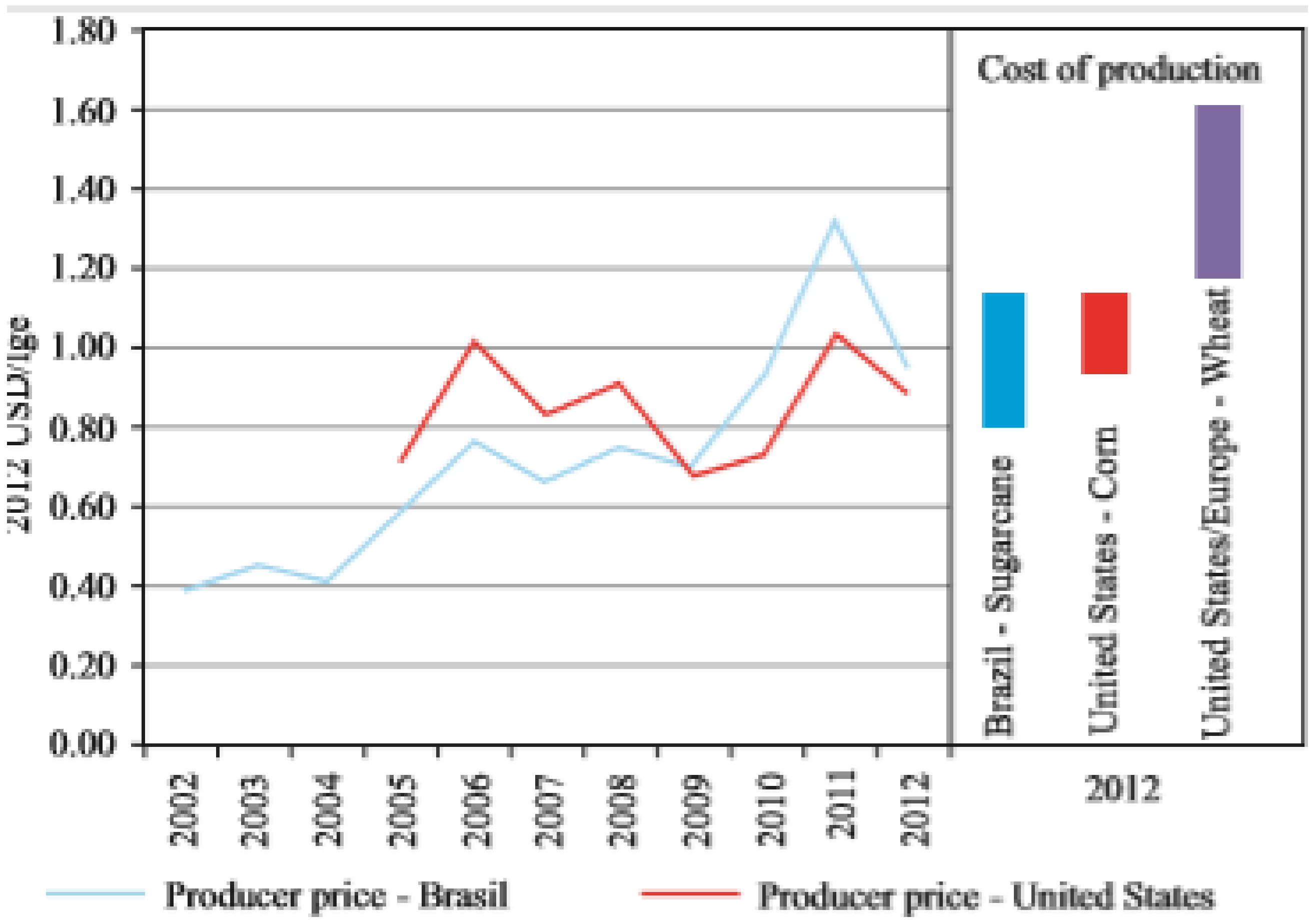
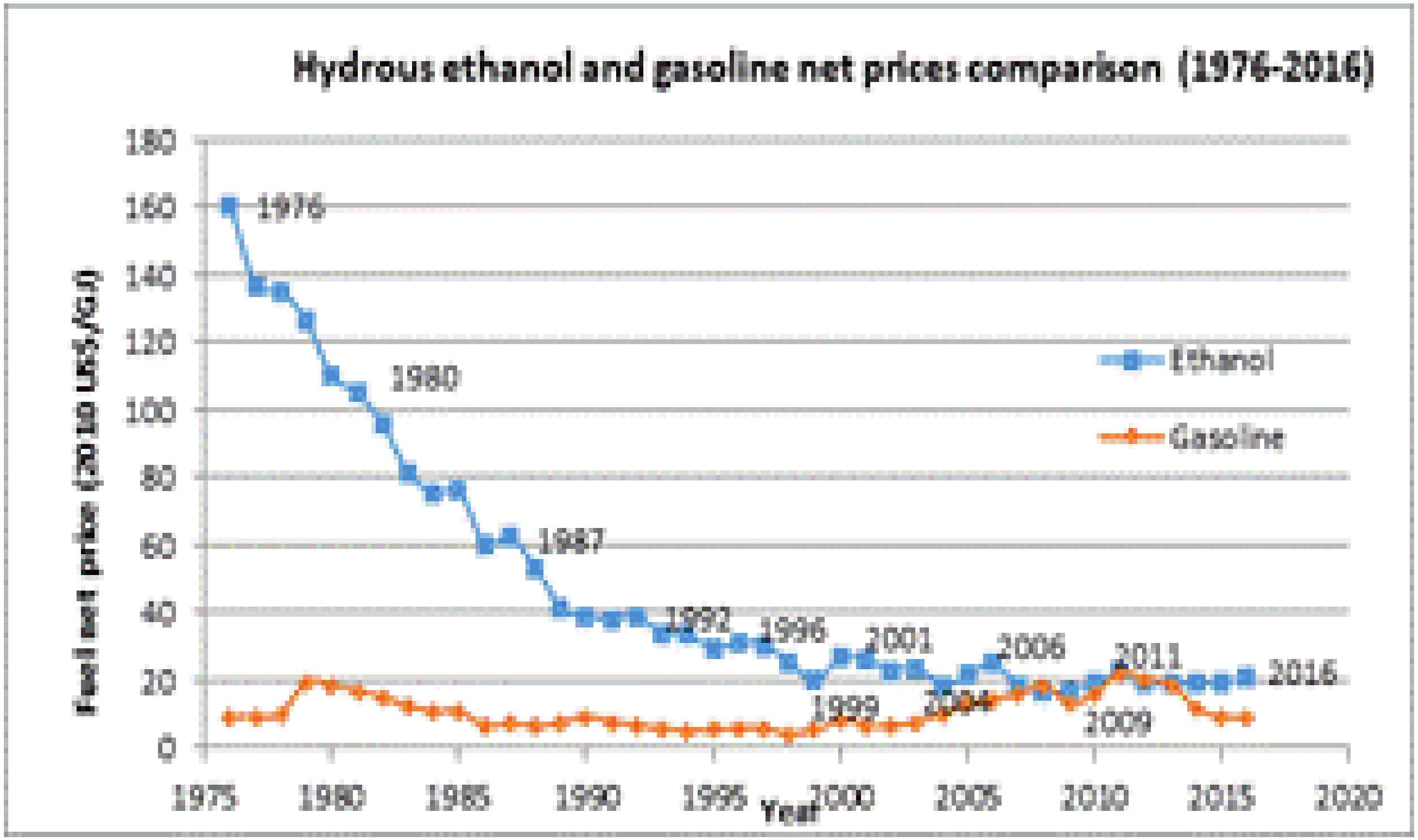
Usinas de etanol em São Paulo



Ethanol production costs for different crops IRENA(2013)



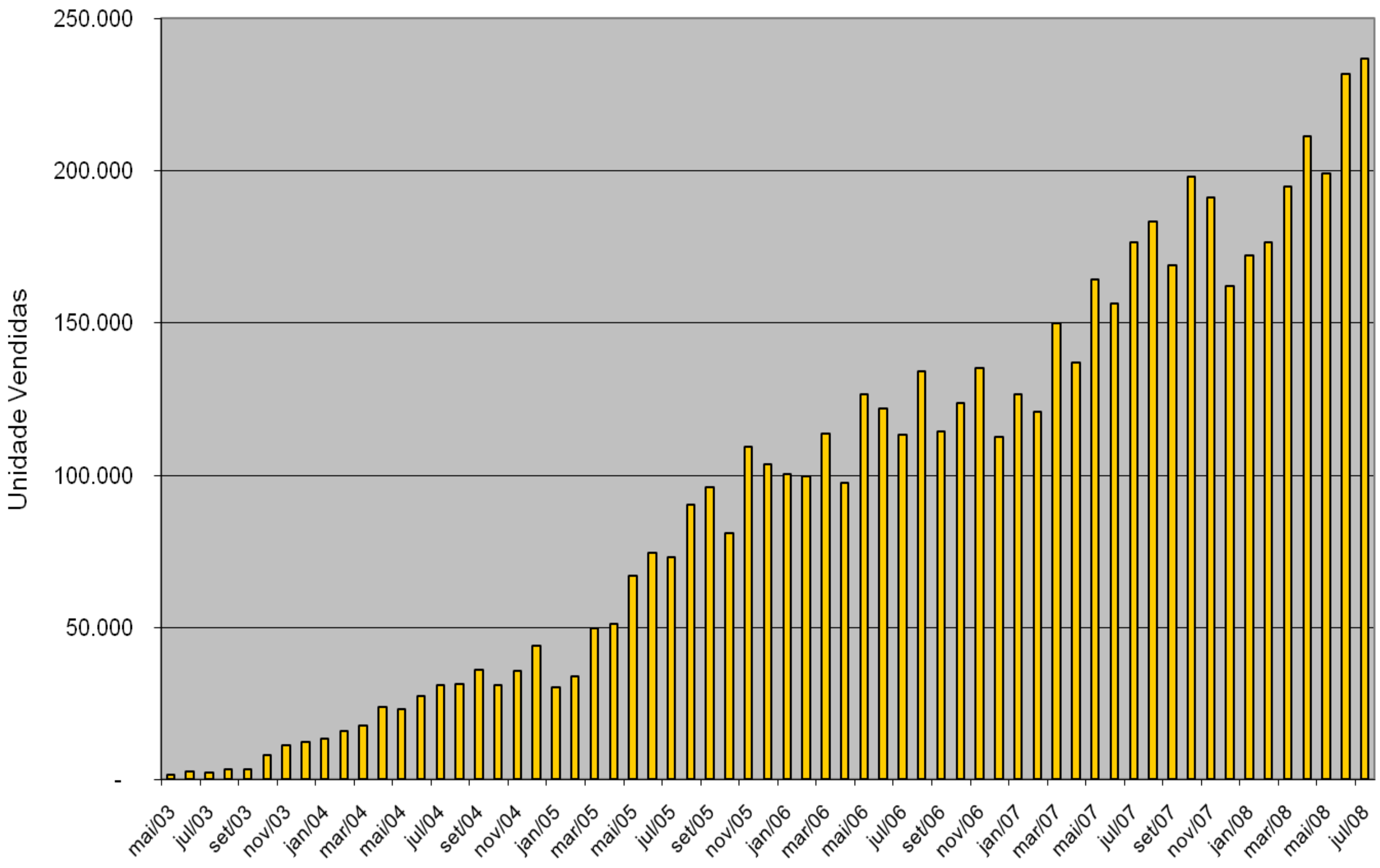
Brazil - Hydrous (sugarcane) ethanol and gasoline (net) prices comparison (1976-2016)



Source: J Goldemberg, P Guardabassi (IEE/USP). Personal Communication (2017)

Uso veicular do etanol

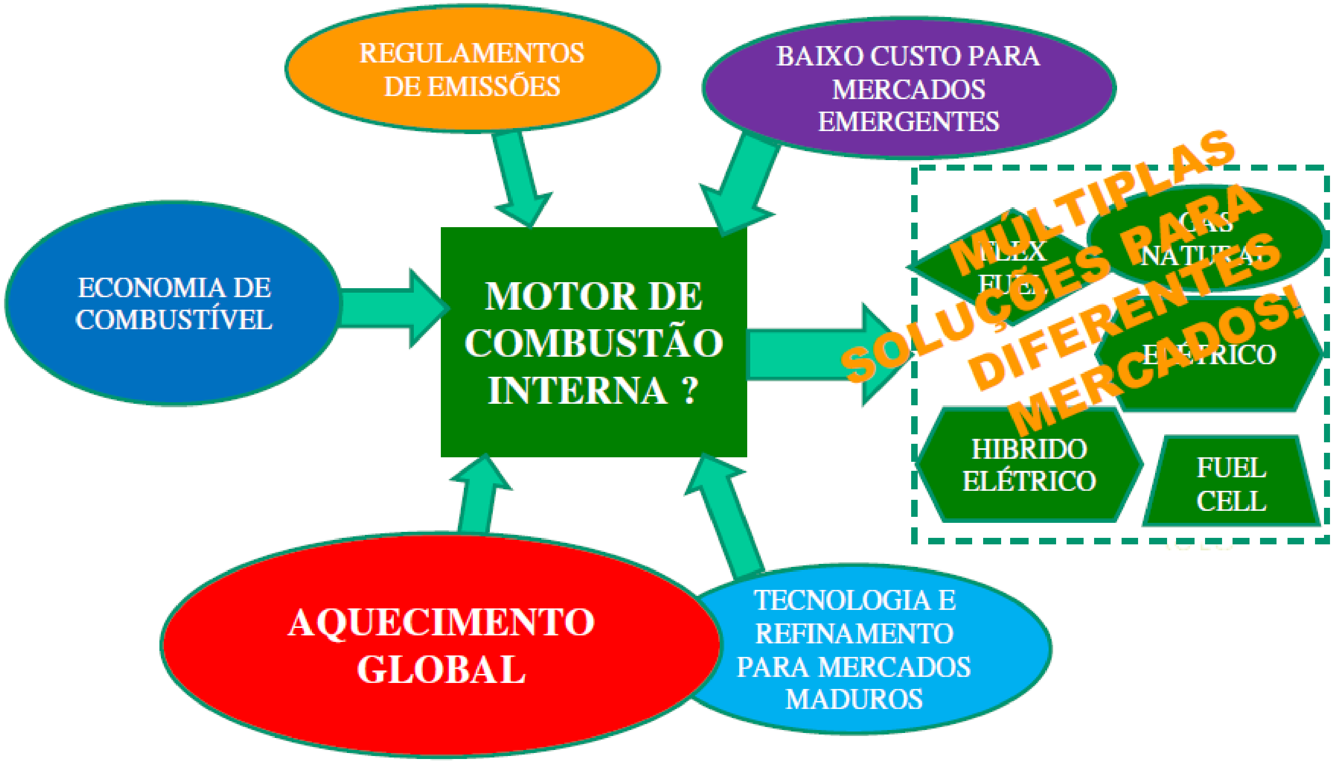
Vendas de Veículos Bicombustíveis (flex)



Fonte: ANFAVEA

VISÃO DE FUTURO

EVOLUÇÃO DOS VEÍCULOS



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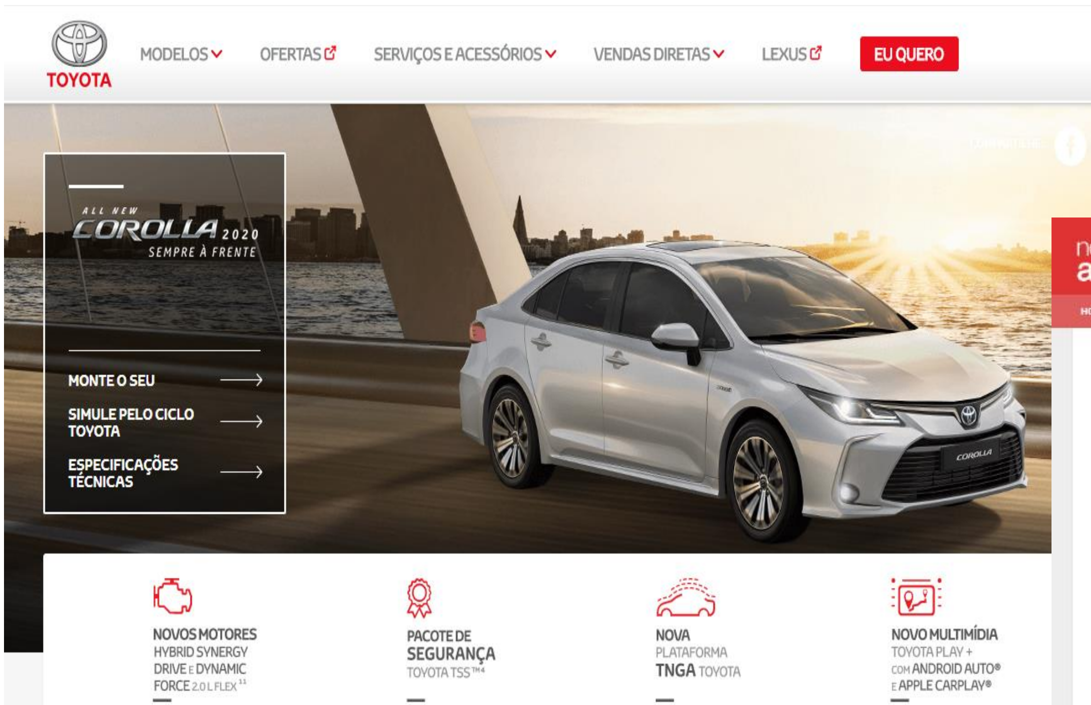
Veiculos hibridos-flex



TOYOTA COROLLA HÍBRIDO FLEX SERÁ FABRICADO EM SÃO PAULO E CHEGA ESSE ANO

Sedã será o primeiro modelo no mundo a adota tal tecnologia. Consumo pode chegar a 30 km/l

por ALEXANDRE IZO

17/04/2019 12h19 - atualizado às 17h02 em 18/04/2019

A Toyota revelou nesta quarta (17) que o Corolla será o primeiro modelo a adotar a tecnologia híbrida flex. **A produção e a estreia do sedã no mercado brasileiro está marcada para o último trimestre do ano,** na fábrica de Indaiatuba (SP), onde é feito atualmente o sedã. O anúncio foi feito no Palácio dos Bandeirantes, sede do Governo paulista, com participação do governador João Dória.

O lançamento é parte da estratégia de investimentos da Toyota que ao todo já aportou **R$ 1,6 bilhão em um período de dois anos.** Destes, cerca de R$ 1 bilhão foi destinado para moderinzar e preparar a fábrica paulista para receber a nova geração do Corolla. E os demais **R$ 600 milhões** teriam sido aplicados nas planta de Porto Feliz (SP).


TOYOTA COROLLA SEDÃ 2020 (FOTO: DIVULGAÇÃO)

AUTO ESPORTE
CARROS ELÉTRICOS E HÍBRIDOS

Toyota confirma que Corolla será 1º carro com motor híbrido flex

https://g1.globo.com/carros/carros-eletricos-e-hibridos/noticia/2019/04/17/toyota-confirma-que-corolla-sera-1o-carro-com-motor-hibrido-flex.ghtml

https://revistaautoesporte.globo.com/Noticias/noticia/2019/04/toyota-corolla-hibrido-flex-sera-fabricado-em-sao-paulo-e-chega-esse-ano.html

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unica
UNIÃO DA INDÚSTRIA DE CANA-DE-AÇÚCAR
ETANOL • AÇÚCAR • ENERGIA SÃO PAULO • BRASIL

ETANOL

NISSAN ESCOLHE BRASIL COMO PLATAFORMA PARA CÉLULA DE COMBUSTÍVEL ALIMENTADA POR ETANOL

30/08/2016

A ampla infraestrutura de produção e abastecimento de etanol existente no Brasil servirá como base para a montadora japonesa Nissan aprimorar uma tecnologia a base de etanol de cana que promete aumentar para 600 quilômetros a autonomia de carros elétricos - igual ao de um modelo a gasolina - sem a necessidade de longos períodos de recarga das baterias. Trata-se do sistema de Célula de Combustível de Óxido Sólido (SOFC, em inglês), que utiliza a reação do oxigênio com o biocombustível (anidro ou com 55% de água) para gerar eletricidade nos veículos.

http://www.unica.com.br/noticia/2003044192034578544/nissan-escolhe-brasil-como-plataforma-para-celula-de-combustivel-alimentada-por-etanol/

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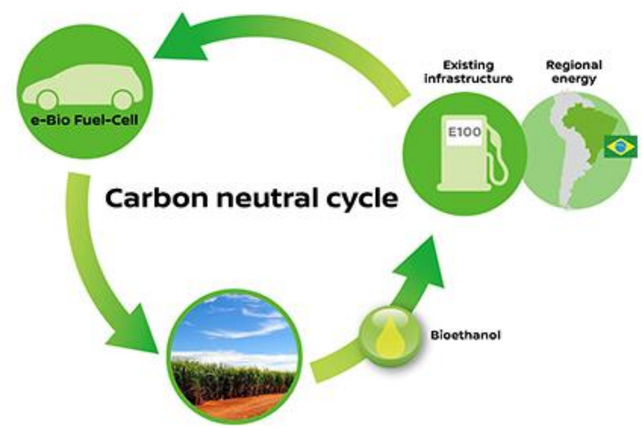
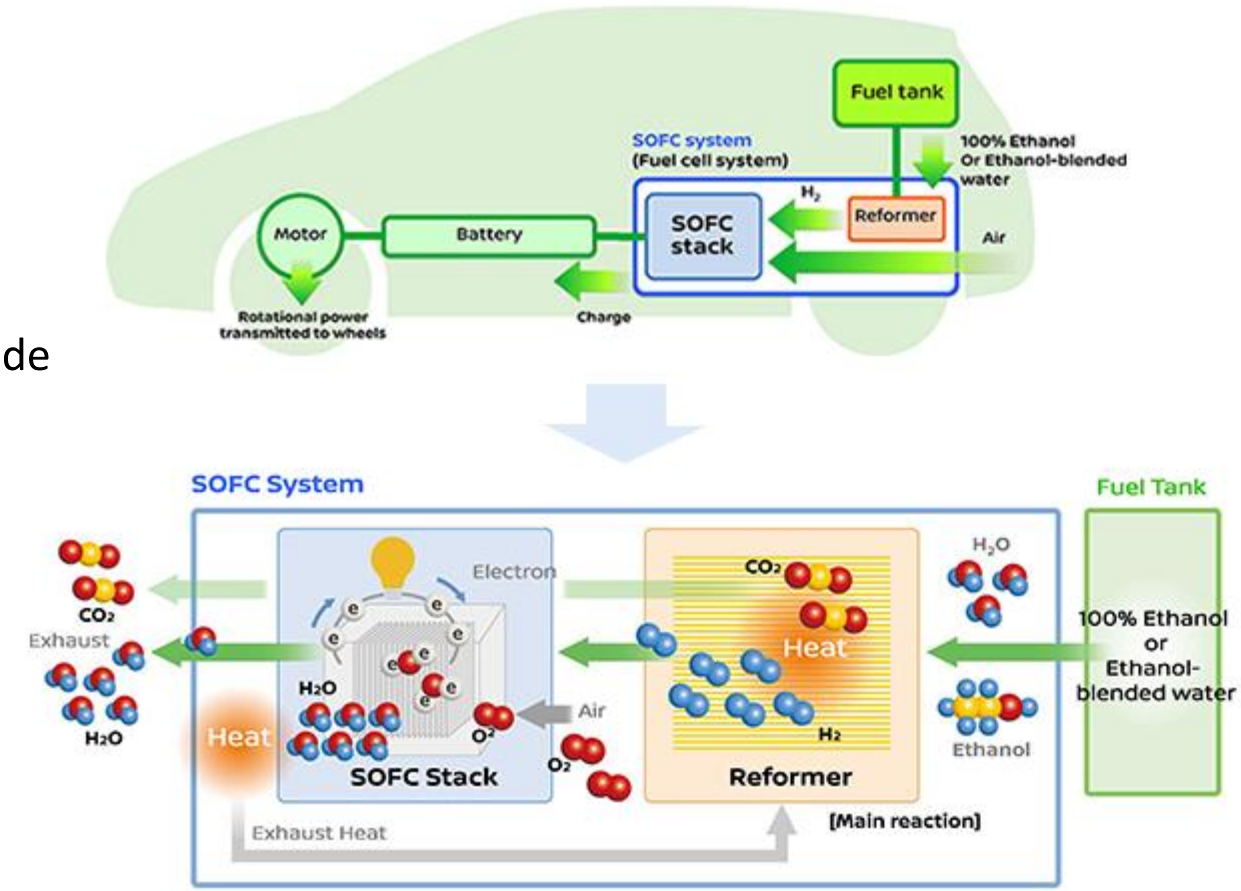
Célula combustível a etanol

A **Nissan** e o Instituto de Pesquisas Energéticas e Nucleares (Ipen) assinaram nesta segunda-feira (18) uma parceria para o desenvolvimento de veículos elétricos com etanol no Brasil.

https://g1.globo.com/carros/carros-eletricos-e-hibridos/noticia/2019/11/25/nissan-faz-nova-parceria-para-desenvolver-carros-eletricos-com-etanol-no-brasil.ghtml



Célula combustível a etanol



SOFC- solid oxide fuel cell

https://www.nissan-global.com/EN/TECHNOLOGY/OVERVIEW/e_bio_fuel_cell.html

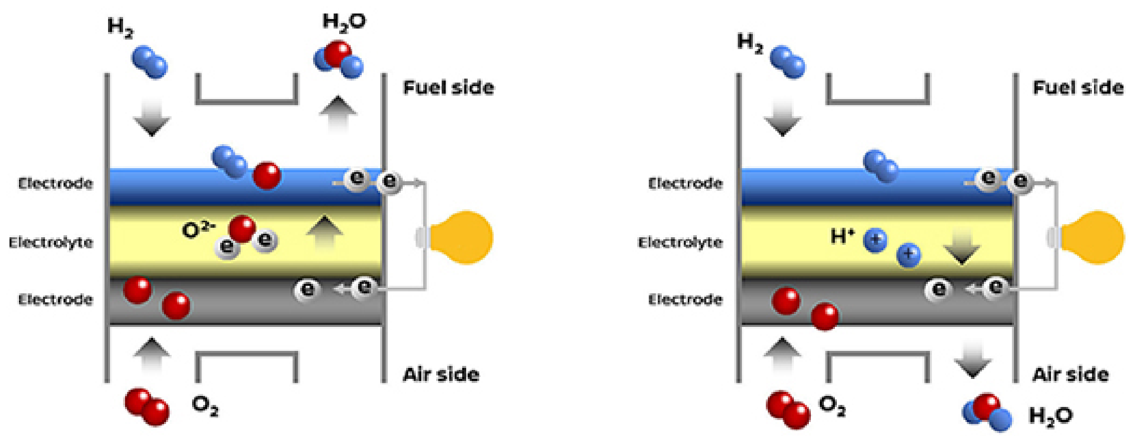
Célula combustível a etanol

System mechanism

Because a SOFC generates electricity from the movement of oxygen ions inside an electrolyte, it is possible to generate electricity from any fuel that reacts with oxygen, and can also generate electricity from low-purity hydrogen. Further, this technology makes it possible to design compact on-board SOFC systems.

Along with ethanol, a wide range of other fuels, such as natural gas, can be a fuel source.

SOFC systems operate at high temperatures, thus making rare metals or other highly active catalysts unnecessary.



SOFC (Solid Oxide Fuel Cell)

Power is generated from the movement of oxygen ions in an electrolyte solution

PEFC (Polymer Electrolyte Fuel Cell)

Power is generated from the movement of hydrogen ions (protons) in an electrolyte solution

https://www.nissan-global.com/EN/TECHNOLOGY/OVERVIEW/e_bio_fuel_cell.html

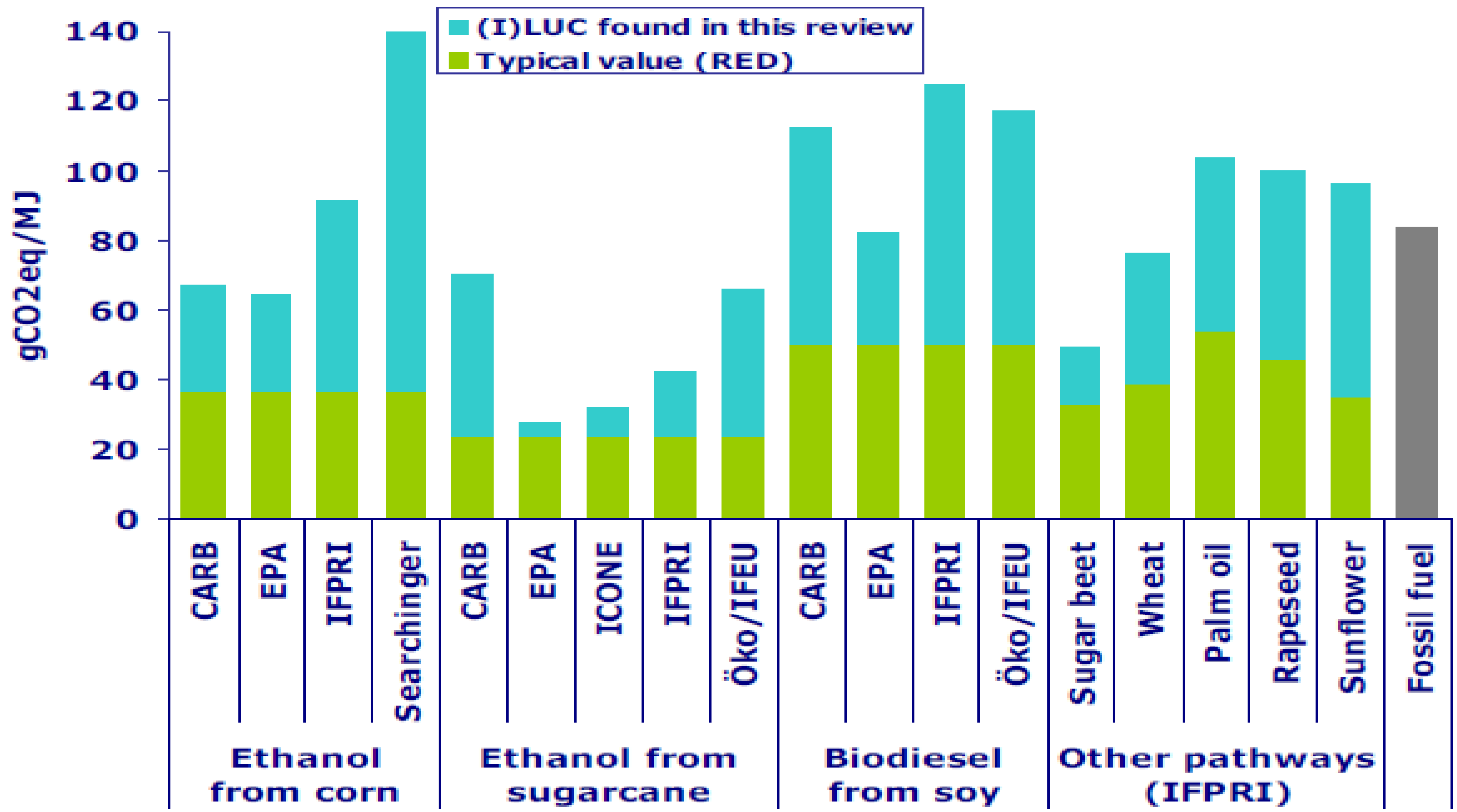


Figure 2 - 2 Graphical representation of the emissions caused by (I)LUC, direct and indirect land use change, for different biofuel pathways and different studies. For reference, typical non-land-use change emissions for the different pathways and a fossil reference from the EU Renewable Energy Directive (RED) have been added.

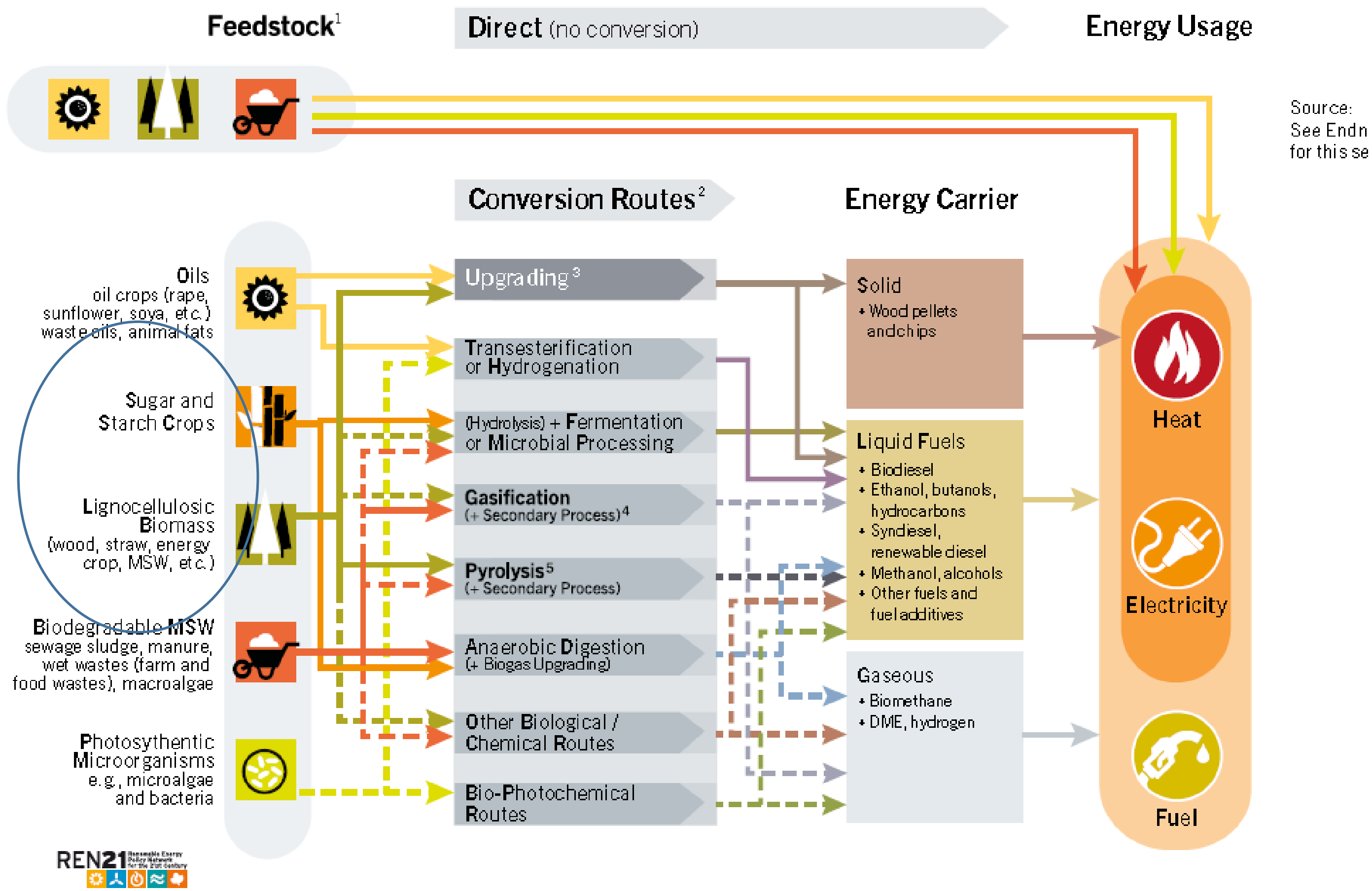
PRODUÇÃO DE ETANOL

- https://www.youtube.com/watch?v=Ghr98yLVoiY

- https://www.youtube.com/watch?v=jIV_JM5M2OM

- https://www.youtube.com/watch?v=m3XS19jeBUw

Figure 6. Bioenergy Conversion Pathways



Note: Solid lines represent commercial pathways, and dotted lines represent developing bioenergy routes.

[1] Parts of each feedstock, e.g., crop residues, could also be used in other routes. [2] Each route also gives co-products. [3] Biomass upgrading includes any one of the densification processes (pelletisation, pyrolysis, torrefaction, etc.). [4] Anaerobic digestion processes release methane and CO_2, and removal of CO_2 provides essentially methane, the major component of natural gas; the upgraded gas is called biomethane. [5] Could be other thermal processing routes such as hydrothermal, liquefaction, etc. DME = dimethyl ether.

Principais Fontes de Carboidratos

- **Diretamente fermentescíveis**
  - GLICOSE (polpa de frutas)
  - FRUTOSE (polpa de frutas)
  - SACAROSE (cana-de-açúcar, beterraba, sorgo sacarino)

- **Indiretamente fermentescíveis**
  - AMIDO (mandioca, milho, grãos de cereais)
  - CELULOSE (madeira, bagaço de cana, palha de arroz, sabugo de milho)

Matérias primas para produção de etanol Brasil

Fonte: Donke, A.C.G. 2016 Dissertação de Mestrado PPGE

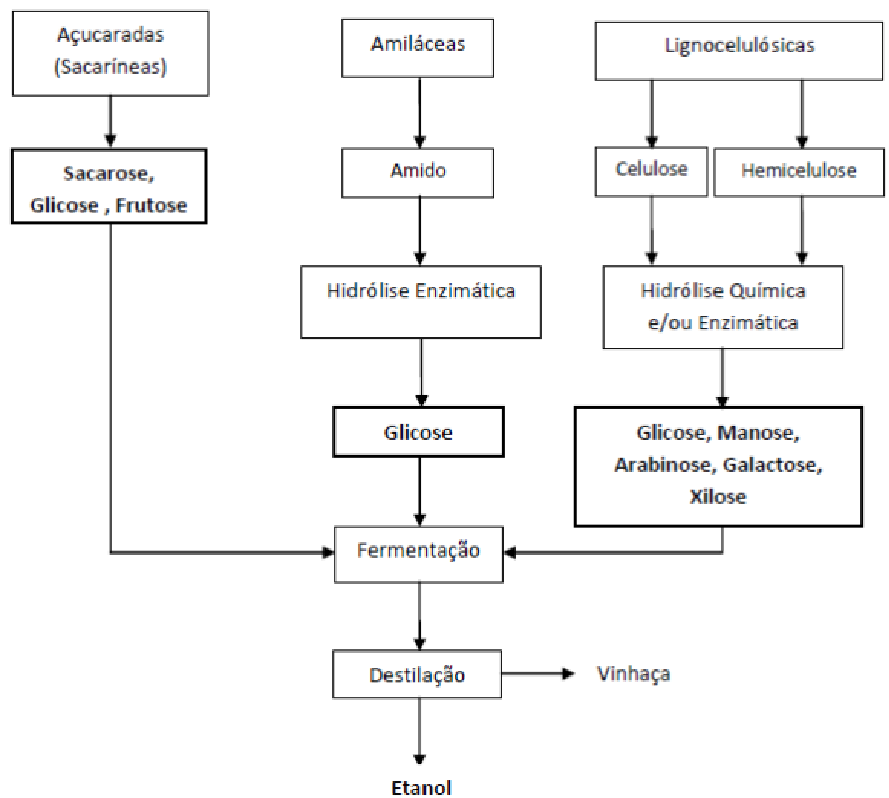
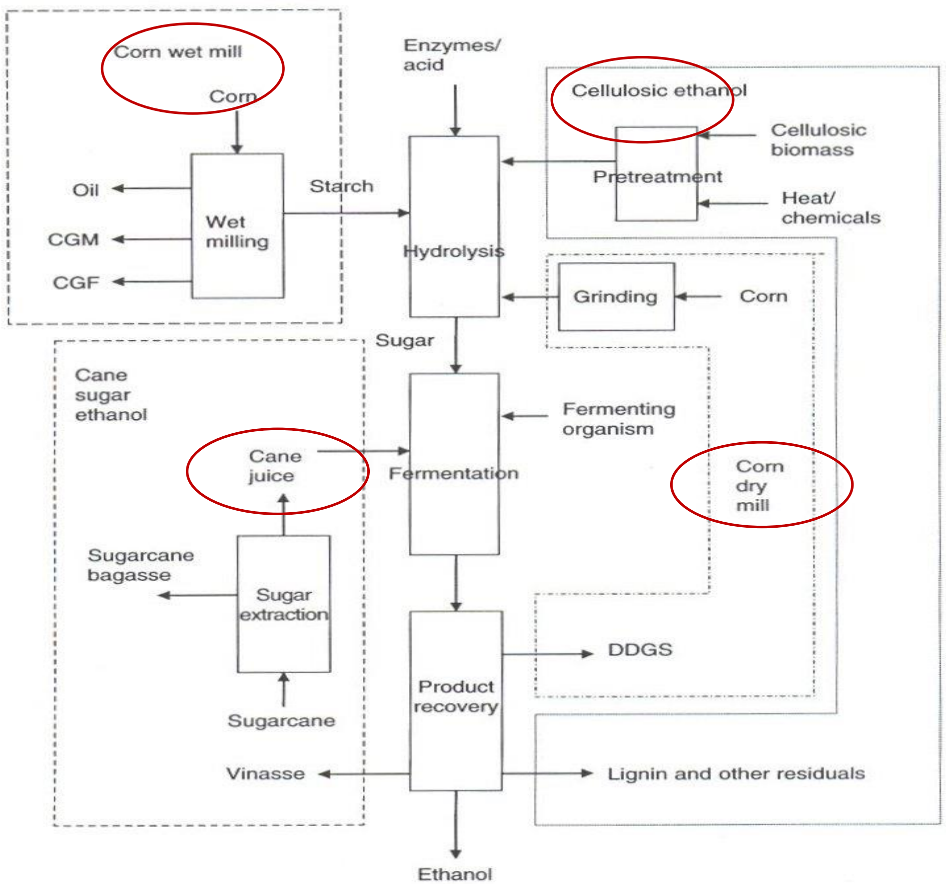
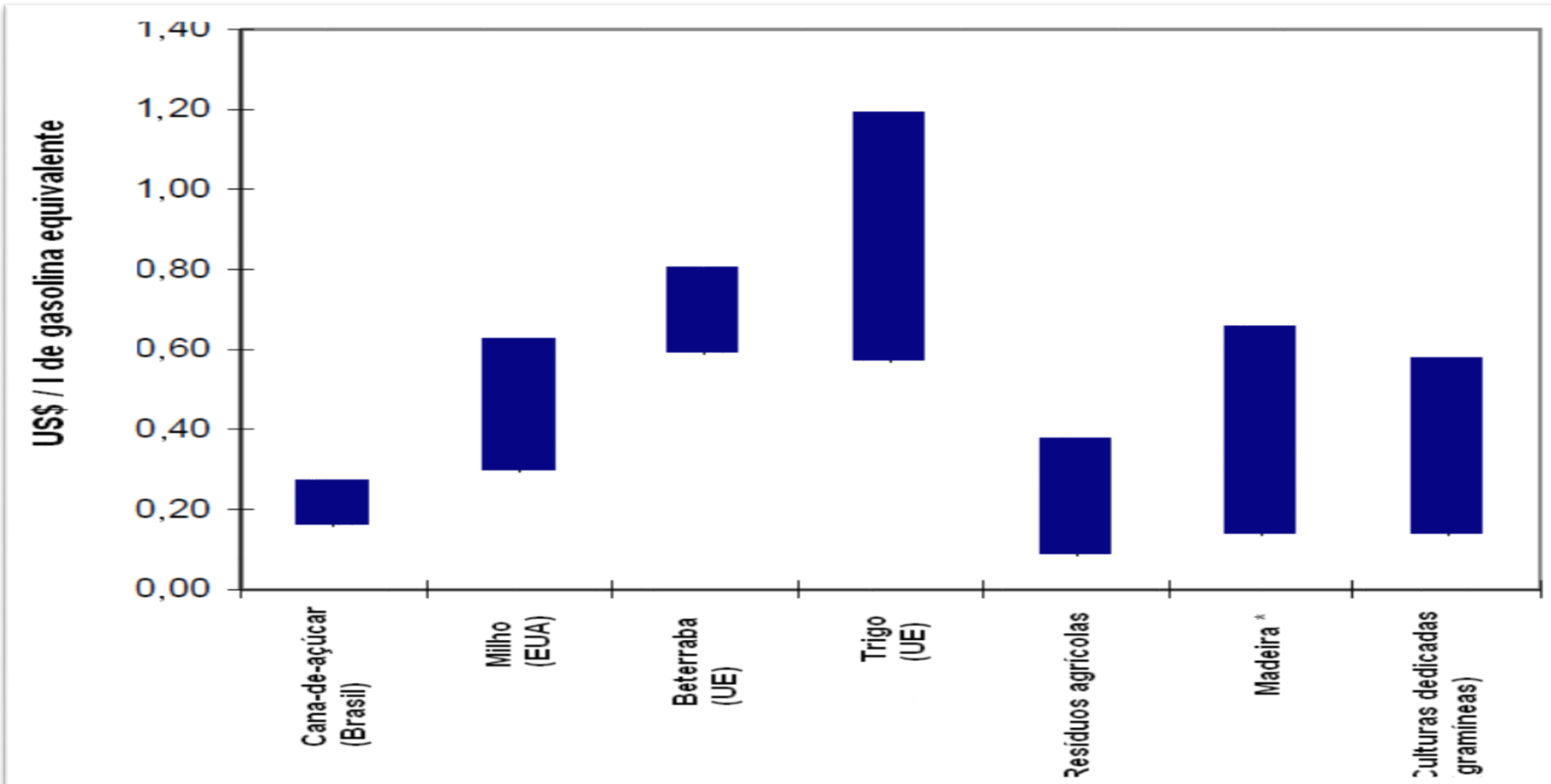


Figura 3.2 - Matérias-primas e seus processos para produção de etanol
Fonte: Pereira Junior, 1991 apud Barcelos, 2012.



Produção de etanol
- cana
- milho

Ethanol production costs from different crops



(CARRIQUIRY et al, 2010)

http://demoplants.bioenergy2020.eu/

Commercializing Liquid Biofuels from Biomass

Task 39 IEA Bioenergy

Database on facilities for the production of advanced liquid and gaseous biofuels for transport

Disclaimer

This database has been elaborated and is maintained by

BEST Bioenergy and Sustainable Technologies

To add your project please contact Dina Bacovsky.

Latest publication based on this database "Status of Advanced Biofuels Demonstration Facilities in 2012"

English | Chinese

Filter Projects

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Search Owner/Name/Input | Submit

Owner	Name	Location	
Aarhus University	Center for Biorefining Technologies	Denmark	Info
Abengoa	Salamanca	Spain	Info
Abengoa	Seville	Spain	Info
Abengoa Bioenergy	demo	Spain	Info
Abengoa Bioenergy Biomass of Kansas, LLC	commercial	United States	Info
Advanced Biofuels Solutions (aquired the	GoGreenGas	United	Info

Map

operational | under construction | planned | non operational | no status

Etanol 2G no Brasil
https://www.youtube.com/watch?v=HLOCSL5xOG8

https://www.youtube.com/watch?v=TSn_12jpWP4

Etanol 3G – algas
https://www.youtube.com/watch?v=vPBcRt9Lh8A

Alagoas inaugura em março primeira usina de etanol de 2ª geração do hemisfério Sul

Publicado em 18 de Fevereiro de 2014

Curtir Compartilhar 67 pessoas curtiram isso.

A empresa GranBio, companhia controlada pela família Gradin com um braço de participação do BNDES, mantém para março a previsão de inauguração em São Miguel dos Campos da primeira usina de etanol de segunda geração de todo o hemisfério sul.

Produzido a partir do bagaço e da palha da cana, o etanol de segunda geração produzido em Alagoas deverá ser o primeiro do país a chegar aos postos de combustíveis. A expectativa do Banco Nacional de Desenvolvimento Econômico e Social (BNDES) é de que a usina em Alagoas seja o pontapé para a produção em escala comercial do etanol de segunda geração em todo país ainda no primeiro semestre. "As únicas plantas que existem hoje deste tipo de etanol estão na Itália e nos Estados Unidos, então o Brasil já pode comemorar um protagonismo em segunda geração similar ao que já tem em primeira geração", disse nessa segunda-feira o gerente do Departamento de Biocombustíveis do BNDES, Artur Yabe, em entrevista a jornalistas após evento de lançamento do chamado PAISS Agrícola.

Segundo o BNDES, com a entrada em operação da usina da GranBio e de outros projetos como o da Raízen (associação entre a Shell e a Cosan), o Brasil já teria potencial para atingir, em 2015, uma produção inicial de 130 milhões de litros. Apesar desse volume representar apenas 0,5% da da produção total de etanol (de primeira geração) do Brasil, a produção seria significativa para fazer o país largar na frente na tecnologia de produção

https://www.youtube.com/watch?v=ufTDAO0OKd8&noredirect=1

NEGÓCIOS *Economia*

Alagoas exportará para a Califórnia etanol feito a partir de bagaço de cana

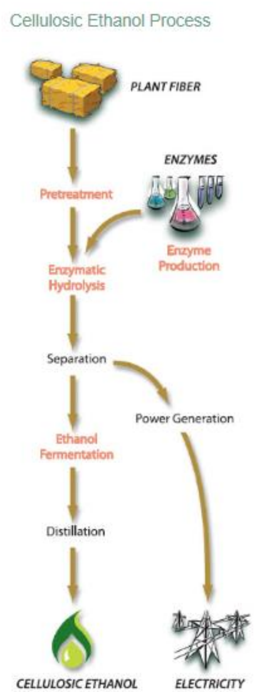
Publicado em 07 de Março de 2014

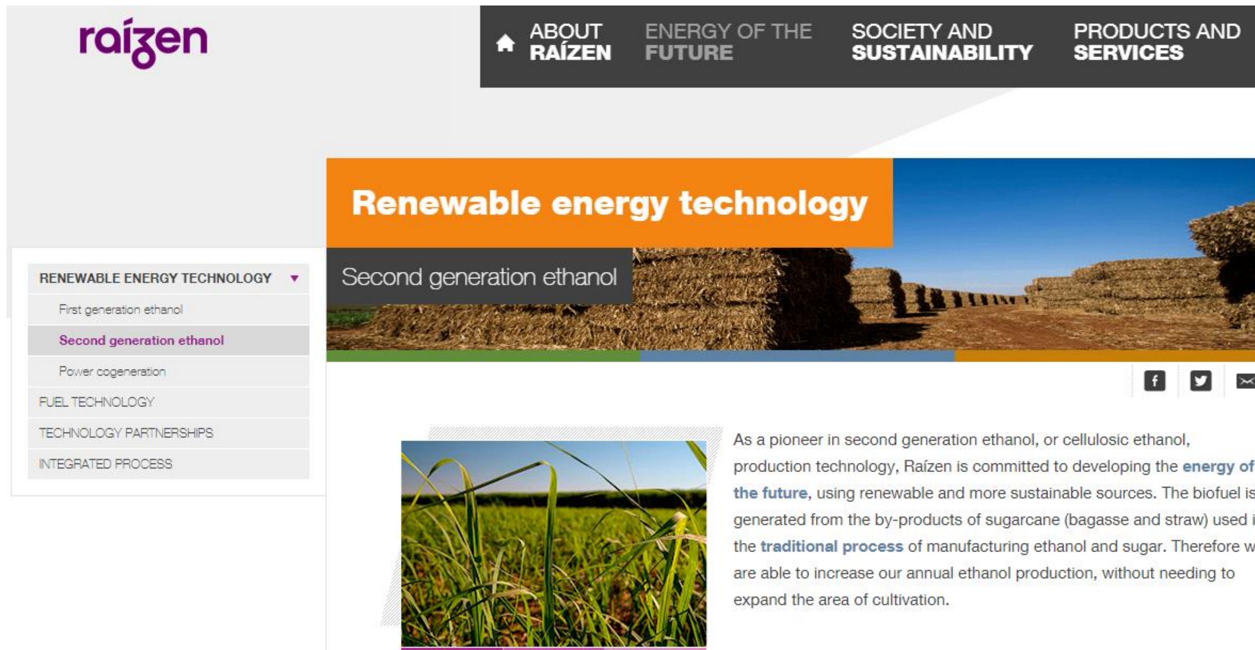
Curtir Compartilhar 99 pessoas curtiram isso.

A GranBio, companhia de biotecnologia controlada pela família Gradin que inaugurará nos próximos dias, em São Miguel dos Campos, a primeira usina de etanol de segunda geração do hemisfério Sul (etanol produzido a partir de bagaço e da palha da cana), afirmou em reportagem publicada nessa sexta no *Valor Econômico* que parte da produção na Usina do Estado deve ser exportada para os Estados Unidos, principalmente para o mercado da Califórnia.

Segundo a reportagem, o plano da empresa é de que a usina em Alagoas seja a primeira de cerca de outras dez que deverão entrar em operação até 2021, com produção anual de 1 bilhão de litros de etanol de segunda geração. "A ideia é exportar pelo menos 50%. Hoje, a Califórnia se apresenta como mercado muito atraente", disse ao jornal o presidente e acionista da empresa, Bernardo Gradin.

Etanol 2G





In November, 2014, we began operating our first industrial plant for the manufacture of biofuel on a commercial scale. Finished in record time, the unit, located in Piracicaba (SP), allows for production of around 40 million more liters of ethanol a year.

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Raízen já ergue usina de etanol de 2ª geração

Nova unidade em Piracicaba vai produzir 40 milhões de litros por ano do biocombustível

Terça, 07 Janeiro 2014 07:38 . Automotive Business

A Raízen vem construindo em Piracicaba (SP) sua primeira unidade de produção de etanol celulósico no Brasil. A nova usina para etanol de segunda geração tem capacidade para 40 milhões de litros por ano. Com investimento de R$ 230 milhões, as instalações entram em operação no quarto trimestre de 2014.

Parte dos recursos foi obtida com o Banco Nacional do Desenvolvimento Econômico e Social (BNDES). O biocombustível de segunda geração é produzido a partir do bagaço, folhas, cascas e outros resíduos da produção de cana-de-açúcar. Com Por ficar ao lado da unidade Costa Pinto, a nova usina terá total c... unidade de primeira geração, reduzindo custos e aproveitand... sistema logístico já existente na região.

CANA | 28 de Novembro de 2013 | atualizado em 28/11/2013

Raízen vai ter usina de etanol de segunda geração em 2014

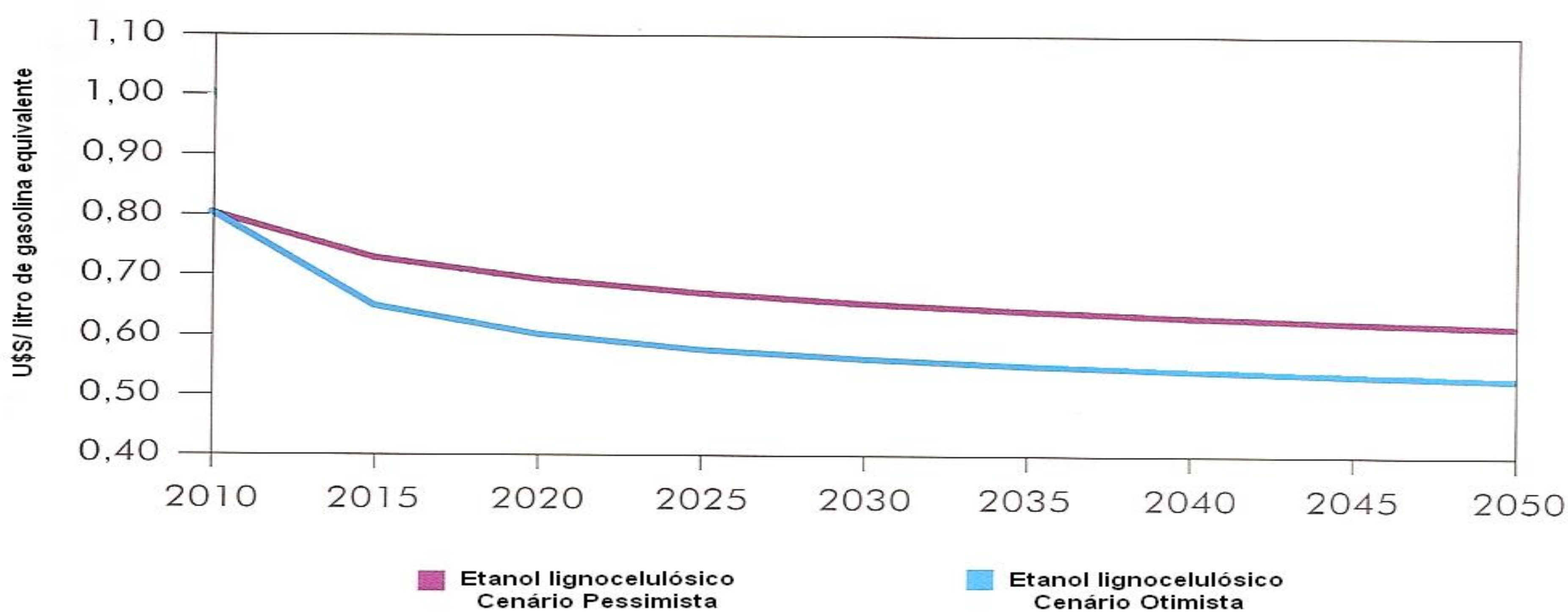
Grupo vai investir R$ 230 milhões para produzir biocombustível a partir de bagaço e palha de cana

POR VIVIANE TAGUCHI

Compartilhar | Tweet 0 | g+1 0 | ASSINE | TAMANHO DO TEXTO A+ A- | Curtir 4

Investimento na unidade será de R$ 240 milhões (Foto: Editora Globo)

Projeções de custos etanol celulósico



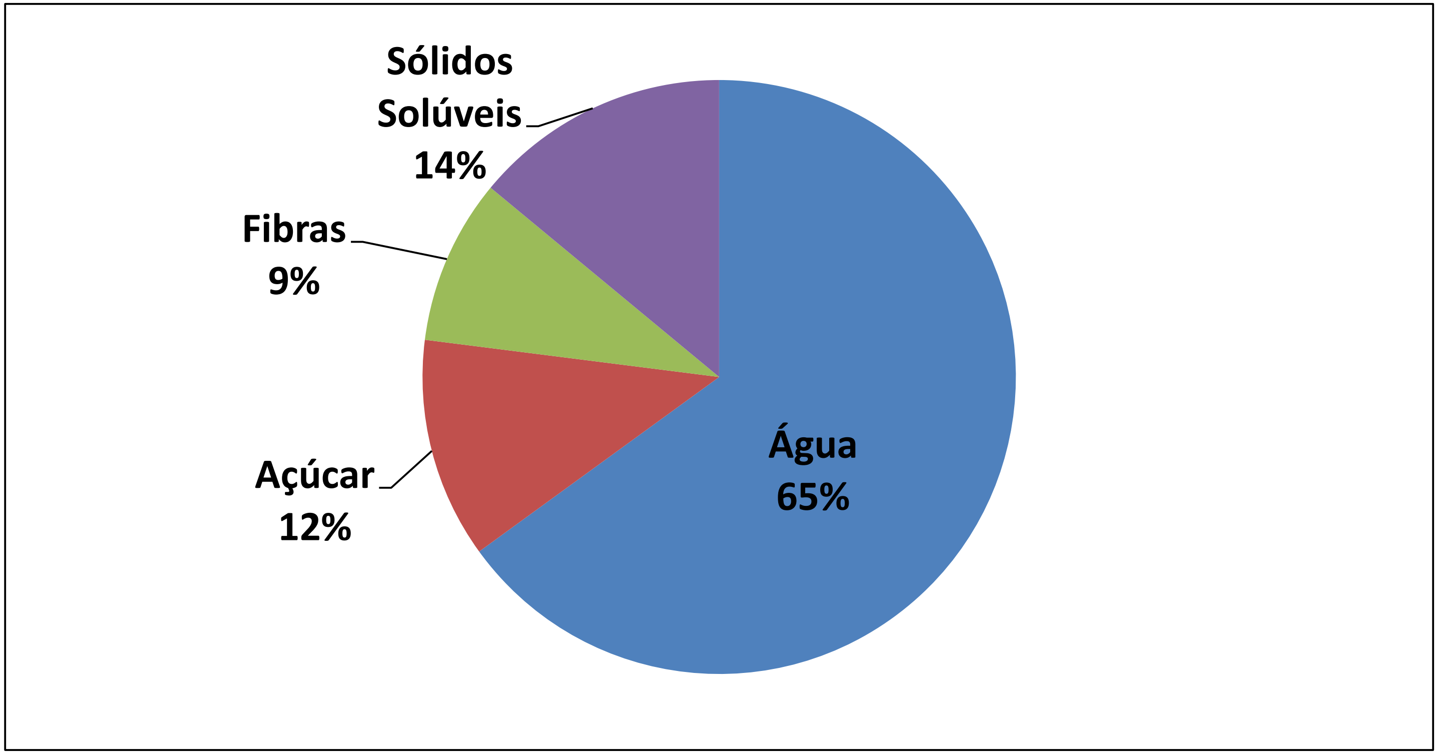
(IEA, 2008)

Etanol de Cana-de-Açúcar

Figura 3.3 - *Saccharum officinarum* L.
Fonte: Navez, 2007.

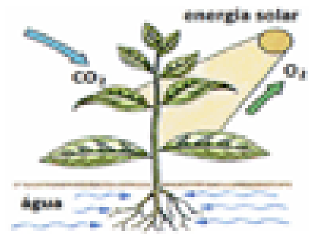
Fonte: Donke, A.C.G. 2016
Dissertação de Mestrado
PPGE

Composição Média da Cana-de-Açúcar



Produção de etanol de cana

Produção de Etanol



$$6\,CO_2 + 6\,H_2O \rightarrow C_6H_{12}O_6 + 6\,O_2$$

Fotossíntese

$$(C_6H_{10}O_5)_n + n(H_2O) \rightarrow n\,C_6H_{12}O_6$$

Sacarificação

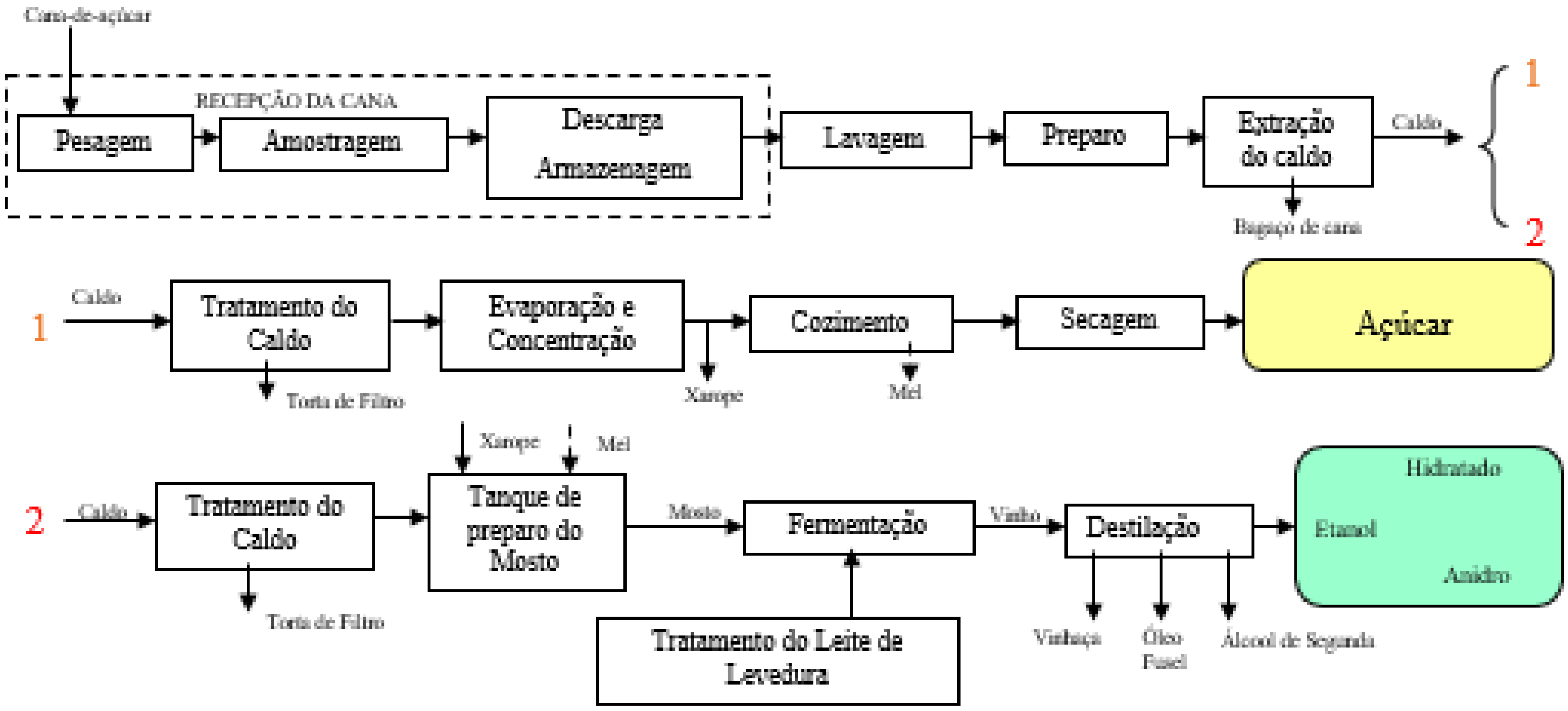
$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$$

Fermentação

Combustão de etanol

- $2C_2H_5OH + 11/2\ O_2 \rightarrow 4\ CO_2 + 5\ H_2O$

Diagrama Simplificado



Fonte: CAMARGO et al., 1990

Anhydrous ethanol production

(through extractive distillation with monoethylene glycol – MEG)

(replacing benzene and cyclohexane)

Santa Elisa mill – Sertaozinho – São Paulo)

Anhydrous ethanol production

Adsortion process (molecular sieve)

Hydrated ethanol passes through a molecular sieve, where water molecules are captured in special resins (zeolites – aluminum silicate)

PENEIRA MOLECULAR

Planta Instalada na COAMO, Campo Mourão - PR - Brasil
Capacidade: 100.000 L/dia

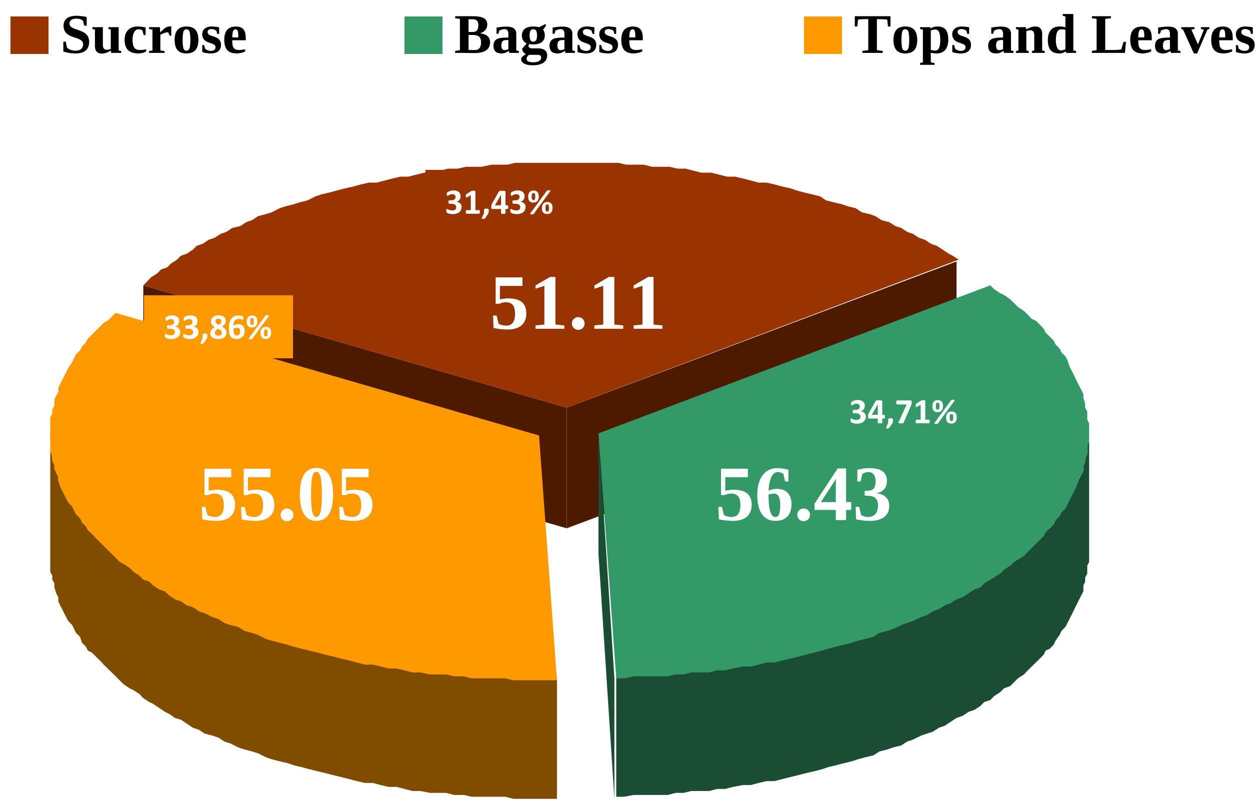
Planta Instalada na Costa Rica

Ribeirão Preto, Segunda-Feira, 14 de Novembro de 2011.

Planalcool Engenharia e Planejamento Industrial S/C Ltda.
Rua Cerqueira César, 481 - 13º Andar - Centro

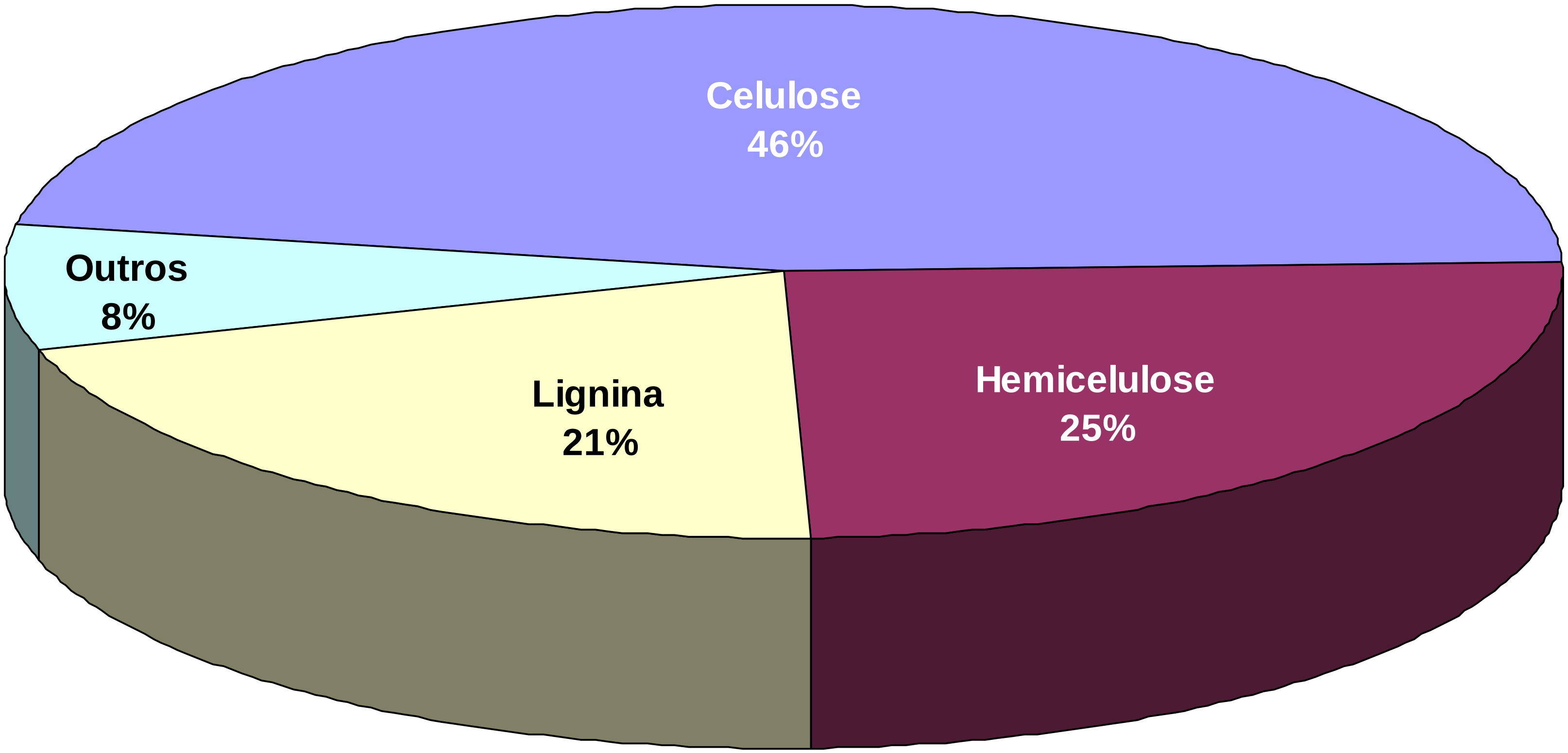
Energy Contained in 1,000 tons of Sugar Cane

(in tons of oil equivalent)

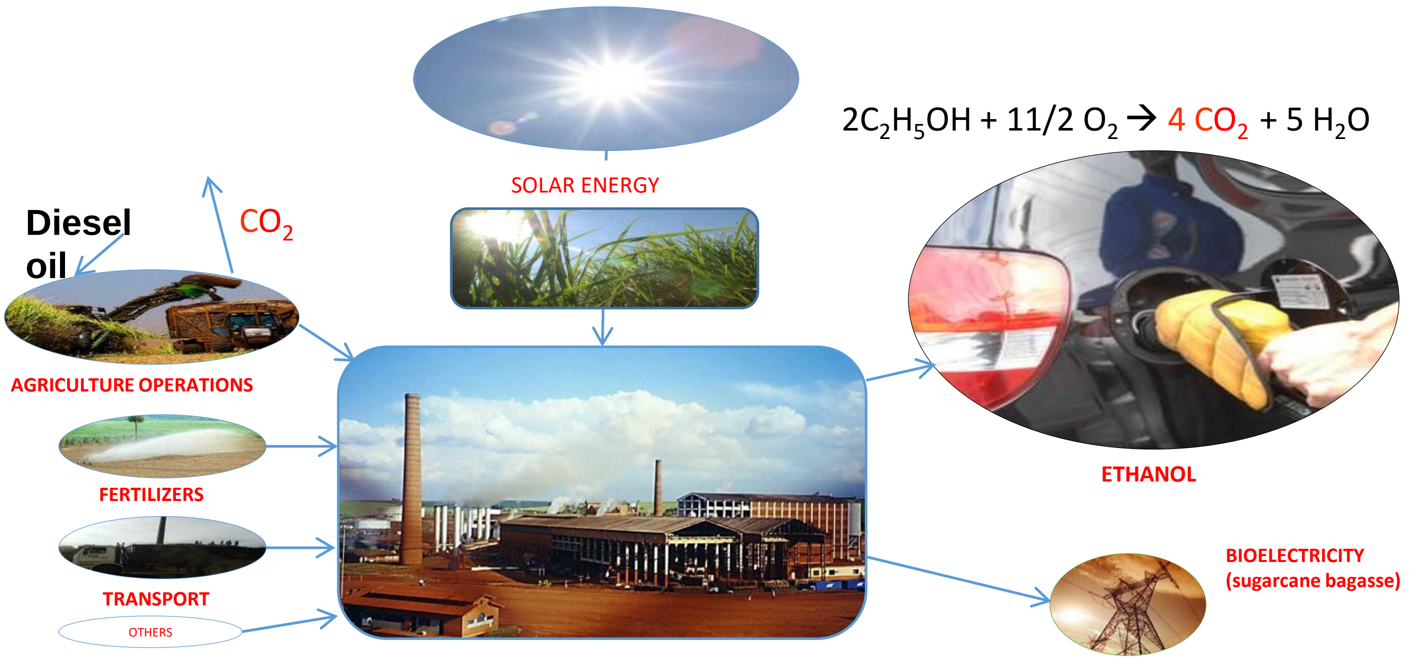


Fonte: Nastari, Lisbon, 2000

Composição do bagaço de cana



Ethanol Energy Balance from Sugarcane

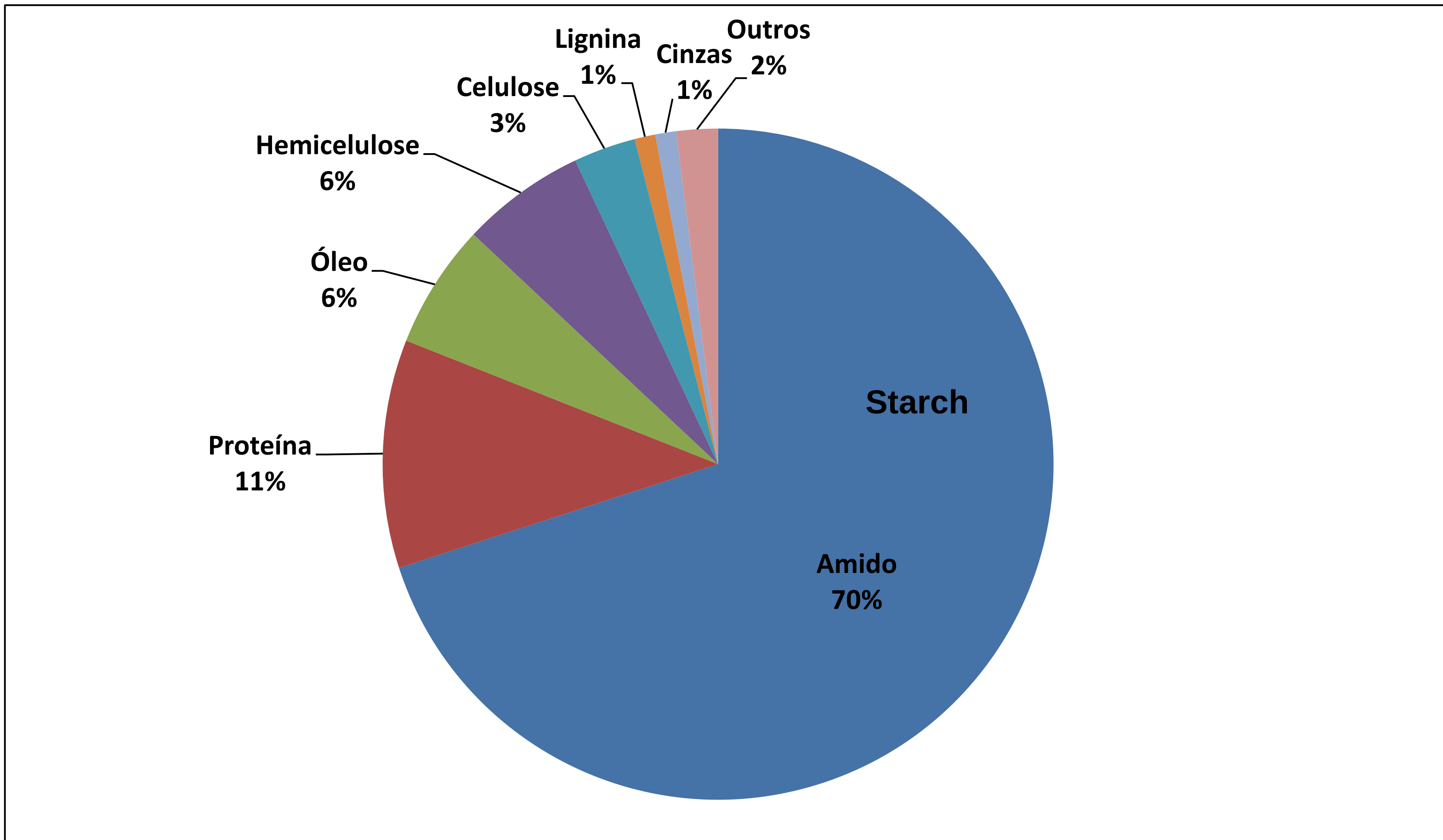


Etanol de Milho

Figura 3.4 - *Zea Mays* L.
Fonte: Zell, 2010.

Fonte: Donke, A.C.G. 2016
Dissertação de Mestrado
PPGE

Corn – chemical composition



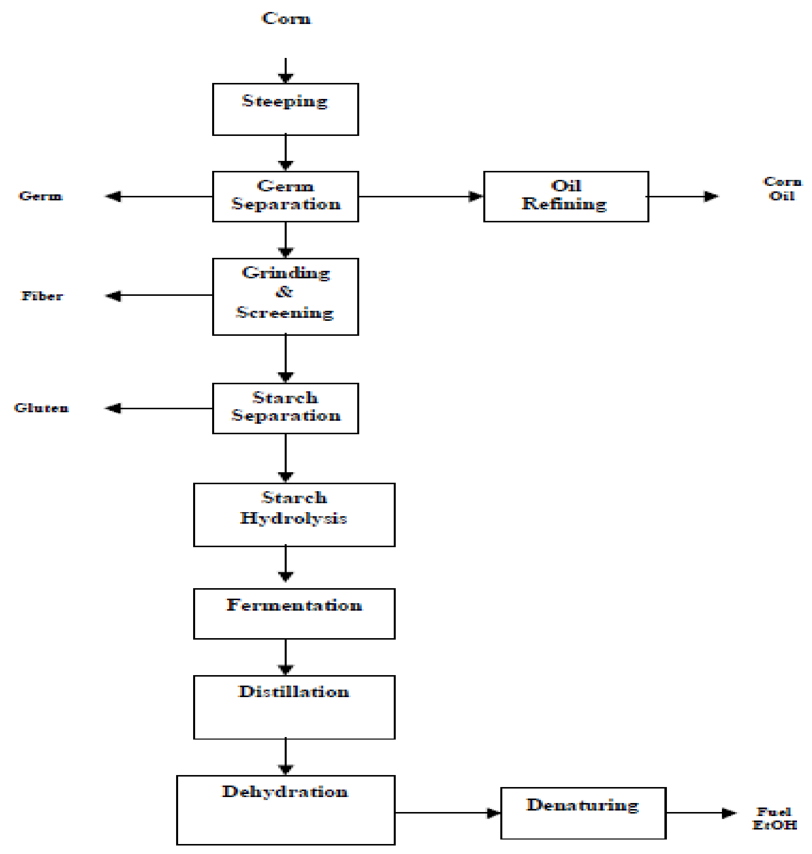
Ethanol production from corn

Corn is the main feedstock for the production of ethanol fuel in the U.S.

Ethanol fuel plant in West Burlington, Iowa.

Etanol de milho - EUA

Figure 2 Corn Wet Milling Process

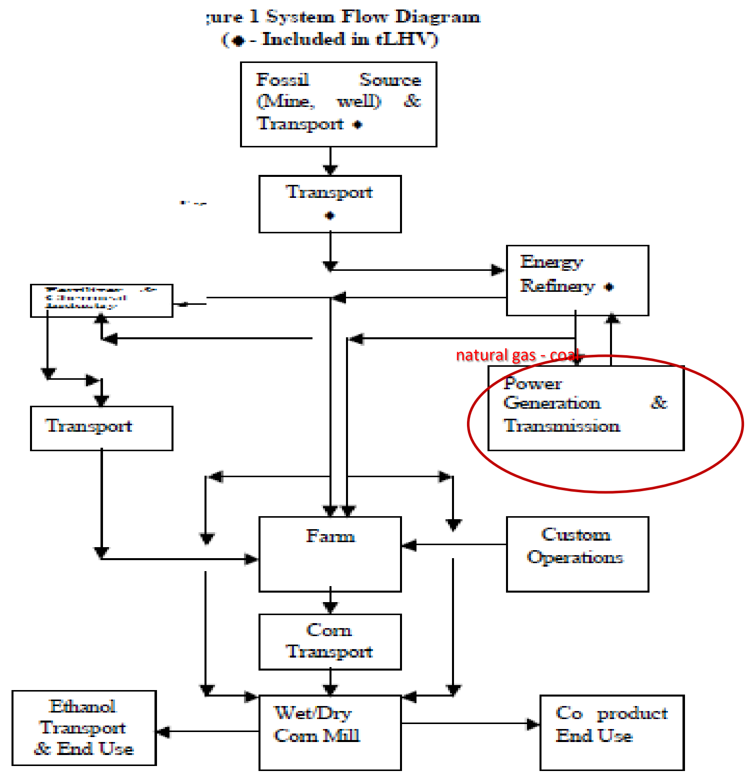


Fossil Energy Use in the Manufacture of Corn Ethanol, August 2002.
Michael S. Graboski. Colorado School of Mines
Prepared for the National Corn Growers Association

Etanol de milho – EUA

- Dry milling:
  - Eletricidade da rede
  - Energia térmica – GN

- Wet milling
  - Cogeração com carvão ou GN



Fossil Energy Use in the Manufacture of Corn Ethanol, August 2002.
Michael S. Graboski. Colorado School of Mines
Prepared for the National Corn Growers Association

Fonte: Donke, A.C.G. 2016 Dissertação de Mestrado PPGE

Etanol de milho no Brasil - MT

Etanol de milho (MT)

Etanol de milho pode corresponder a 50% da produção no Mato Grosso em 2020

11/04/2019 07:07:00

Mato Grosso Mais
Jornalismo Sério

ÚLTIMAS NOTÍCIAS GERAL POLÍTICA POLÍCIA JUDICIÁRIO ESPORTE QUENTINHAS VARI

14 DE MARÇO DE 2019 - 15:32

SUSTENTÁVEL

Usina de etanol de milho deve produzir 200 milhões de litros por ano em MT

Segundo o Sindialcool, a moagem de cana na última safra do estado foi de 17.186.982 toneladas com previsão de um pequeno aumento para próxima safra, elevando a moagem para aproximadamente 17.500.000 toneladas.

Quanto ao milho, para a última safra (2018/2019) a expectativa de moagem é de 1.750.000 toneladas. Os dados de moagem de milho das ultimas 5 safras mostram que o aumento é exponencial.

Fonte: Workshop SEBRAE/GBIO, 2019

Etanol de milho (MT)

Usina Porto Seguro: produz etanol tanto a partir da cana-de-açúcar quanto de milho – por esse motivo é chamada de usina “flex”

Caldeiras queimam cavaco de madeira de floresta plantada – menores emissões de GEE

Fonte: visita de campo GBIO,2019.
Projeto BIOMAT GBIO/SEBRAE

Etanol de Sorgo

- sorgo sacarino (açúcares fermentescíveis-etanol),
- sorgo forrageiro (alimentação animal),
- sorgo granifero/bicolor (amido- etanol)

Figura 3.5 - *Sorghum bicolor* L. Moench
Fonte:Döhne, 2008.

Fonte: Donke, A.C.G. 2016 Dissertação de Mestrado PPGE

Usina integrada em Mato Grosso

Fonte: Donke, A.C.G.
2016
Dissertação de
Mestrado
PPGE

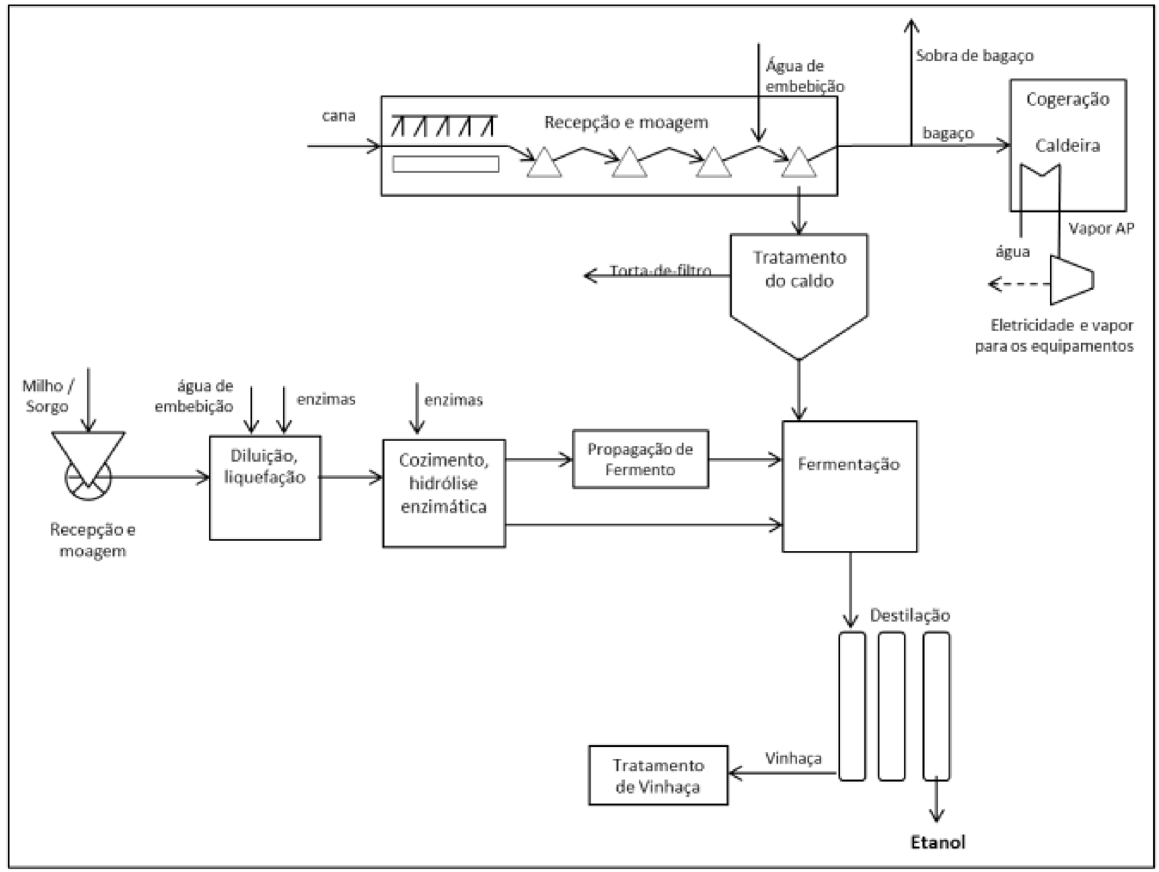
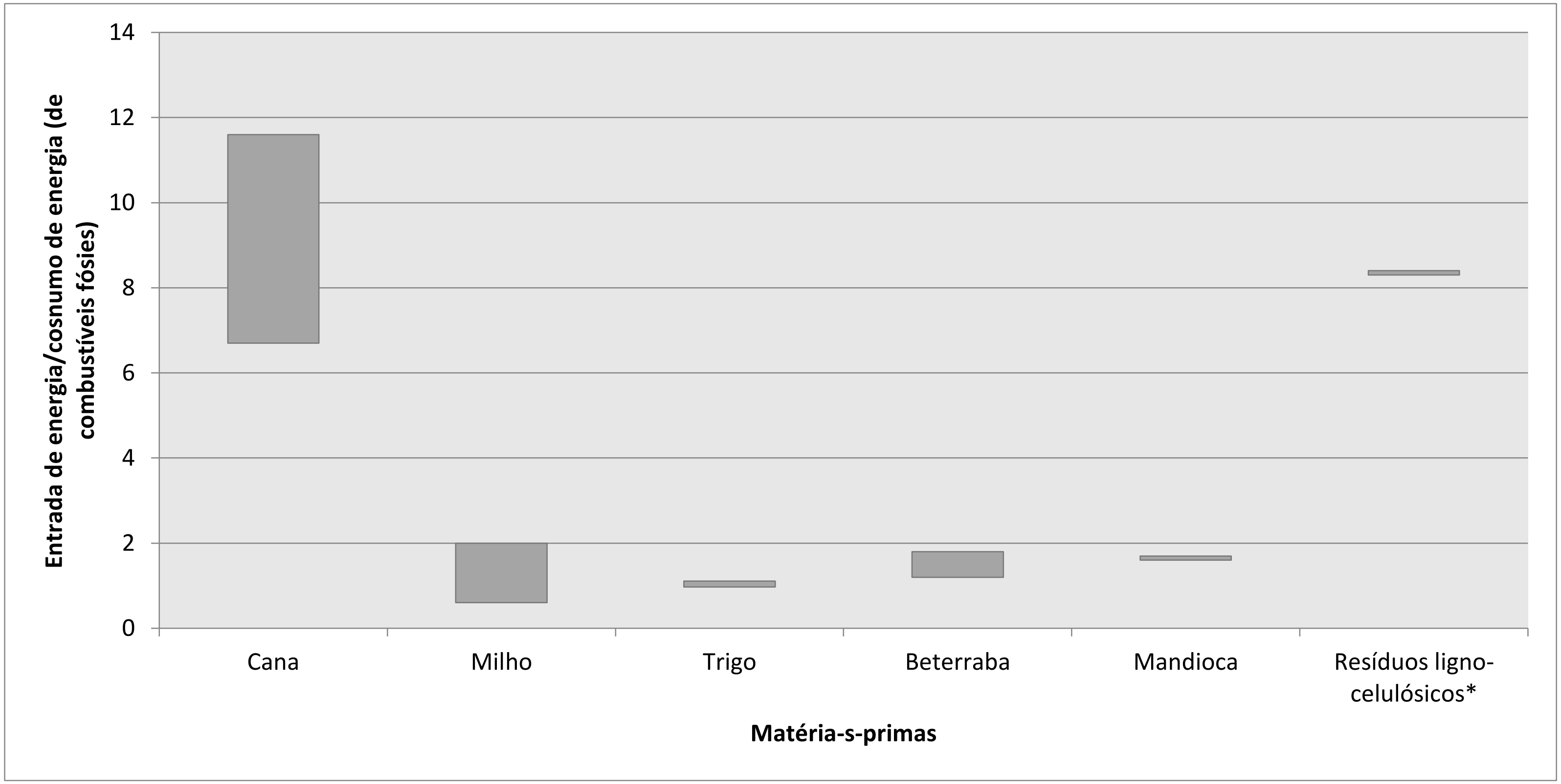


Figura 3.1. Esquema ilustrativo de uma Usina Flex ou Usina Integrada

Balanço de energia do etanol de diferentes matérias primas

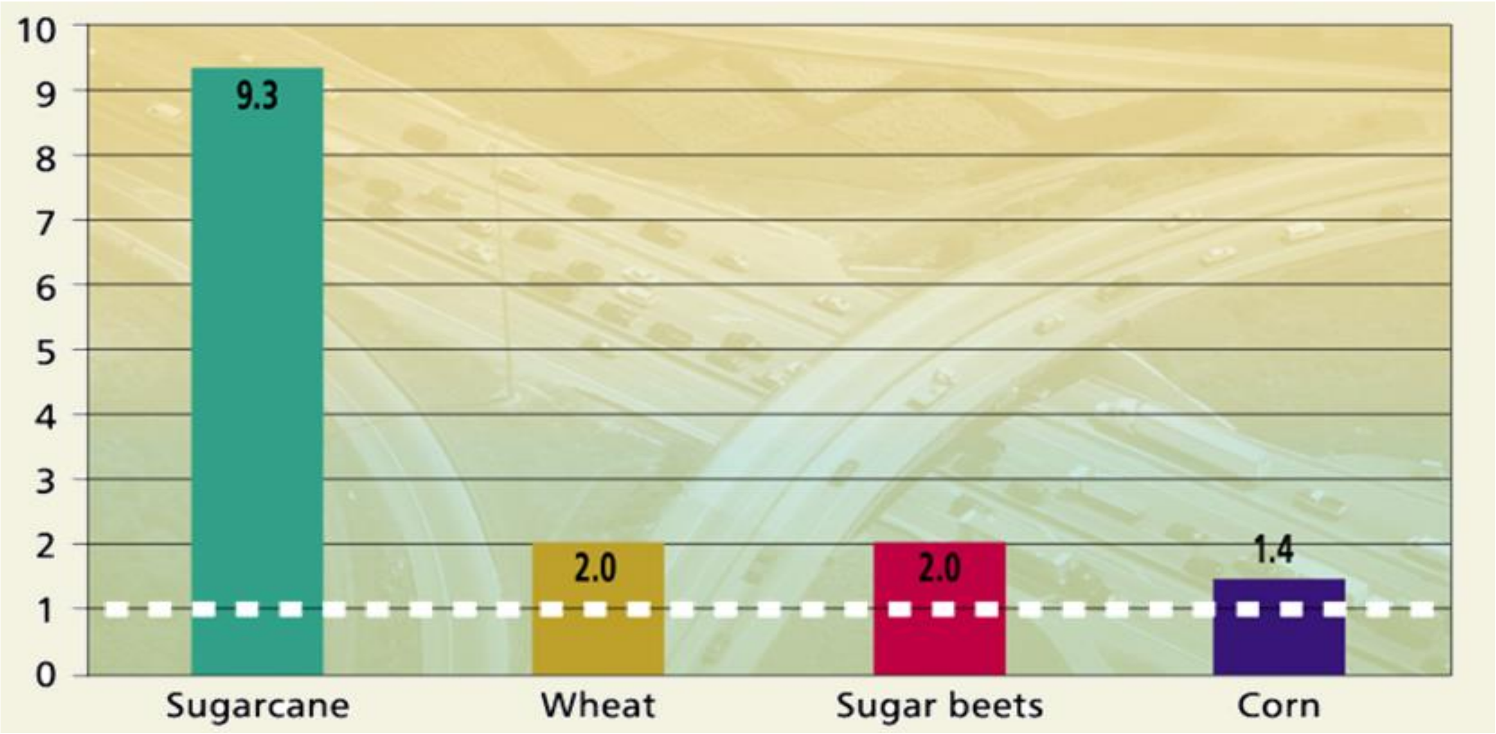
Balanço de energia = energia produzida com o etanol/energia consumida de origem fóssil



* Estimativa teórica, tecnologia em desenvolvimento

Fontes: Dai et al, 2006; EBAMM, 2005; IEA, 2004; Macedo et al, 2007 e Nguyen et al, 2007

Ethanol Energy Balance for Different Crops



Source: World Watch Institute (2006) e Macedo et al. (2008).
Elaboration: UNICA

GHG emissions avoided with gasoline replacement

Feedstock	Avoided emissions
Sugarcane	61% to 82%
Corn	-30% to 38%
Wheat	19% to 47%
Sugar Beet	35% to 56%
Cassava	63%
Lignocellulosic residues*	66.5% to 73%

- UNICA (2010) - including iLUC - sugarcane ethanol has a reduction of GHG emissions of 73-82% compared with gasoline, on a 30- or 100-year time horizon, respectively.	- EPA's calculations - sugarcane ethanol from Brazil reduces GHG emissions compared to gasoline by 61%, using a 30-year payback for iLUC emissions

http://english.unica.com.br/news/38990375920334398749/epa-reaffirms-sugarcane-biofuel-is-advanced-renewable-fuel-with-61-por-cento-less-emissions-than-gasoline/

* In theory – technology under development
Sources: Dai et al, 2006; EBAMM, 2005; IEA, 2004; Macedo et al, 2007 e Nguyen et al, 2007

Ethanol Life Cycle Emissions (2004)

	($kg\ CO_2eq./TC$)	
	Scenario 1 (average)	Scenario 2 (best values)
Type		
Fossil fuels	19.2	17.7
Methane and N_2O from trash burning	9.0	9.0
Soil N_2O	6.3	6.3
Total emissions	34.5	33.0
Avoided emissions		
Surplus bagasse use	12.5	23.3
Ethanol use	242.5 (A); 169.4 (H)	259.0 (A); 180.8 (H)
Total avoided emissions	255.0 (A); 181.9 (H)	282.3 (A); 204.2 (H)
Net avoided emissions	220.5 (A); 147.4 (H)	249.3 (A); 171.1 (H)

(A): Anhydrous ethanol

(H): Hydrous ethanol

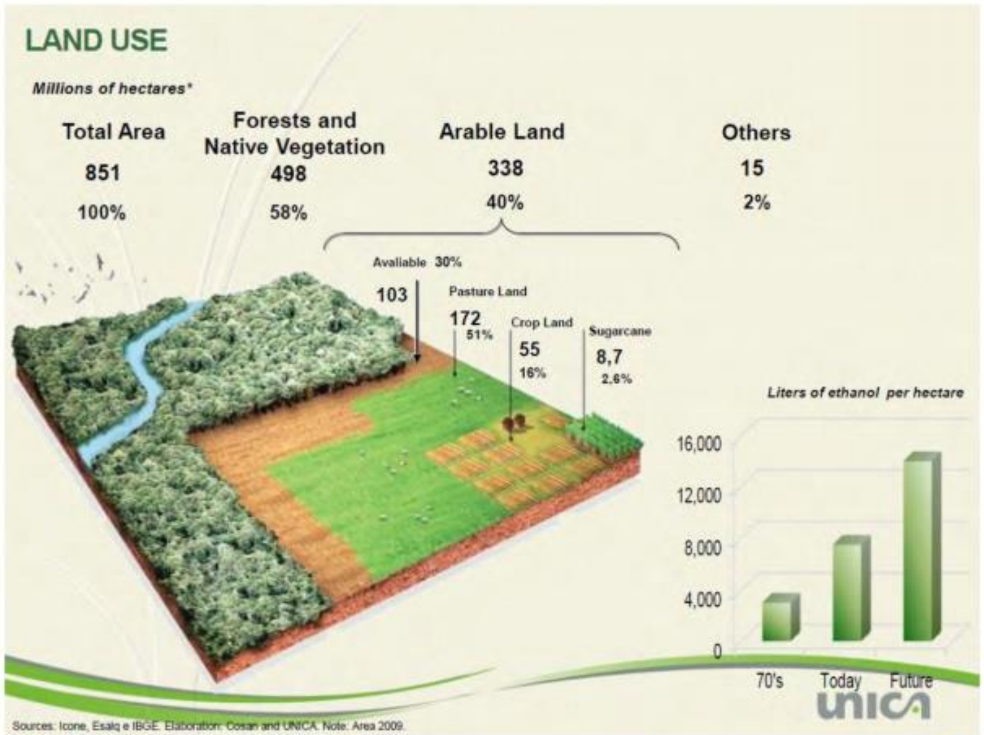
GHG emissions reduction: up to 90%
Average energy balance: up to 8.0 (year 2004) - 9.3 (year 2006)

Source: Macedo et al, 2004, 2008

Impact on Biodiversity and Ecosystem

Soybeans: ~ 30 Mha

Sugarcane: 8.7 Mha
For ethanol and sugar
Brazil:
#1 sugar exporter
(> 1/3 of total global exports)
Produces 17% of global consumption



Pesquisar os resultados do **balanço energético do etanol de cana, milho e sorgo** no MT

Referencia
(Ana Cristina Guimarães Donke. Avaliação do desempenho ambiental e energético na produção de etanol decana, milho e sorgo em uma unidade integrada pela abordagem de ciclo de vida. Dissertação de mestrado. PPGE/IEE/USP. 2016)

Comentar as diferenças entre MT e SP

Portal Brasil

Perguntas frequentes

VOCÊ ESTÁ AQUI: PÁGINA INICIAL > INFRAESTRUTURA > 2017 > 02 > RENOVABIO VAI EXPANDIR PRODUÇÃO DE BIOCOMBUSTÍVEL NO PAÍS

- Últimas notícias
- Portal Planalto
- Navegue por Estados
- BrazilGovNews

ASSUNTOS

- Cidadania e Justiça
- Ciência e Tecnologia

INFRAESTRUTURA

RenovaBio vai expandir produção de biocombustível no País

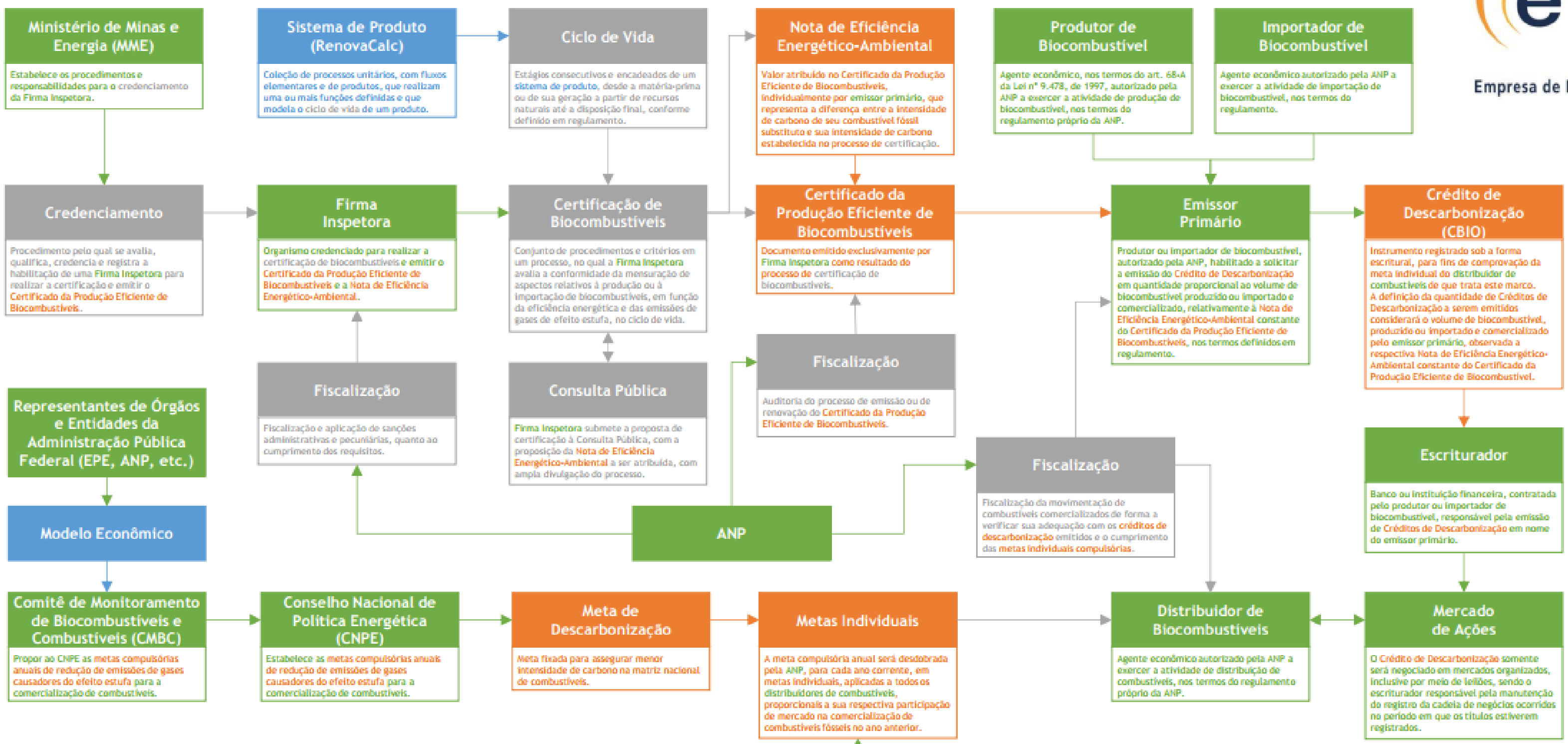
Energia

Programa também vai ajudar no processo de redução de 43% das emissões de gases de efeito estufa até 2030

http://www.brasil.gov.br/infraestrutura/2017/02/renovabio-vai-expandir-producao-de-biocombustivel-no-pais

Fluxograma RenovaBio

Empresa de Pesquisa Energética



To incentivize biofuels producers efficiency based on carbon footprint – LCA of the biofuel process

RenovaBio: incentive to reduce carbon footprint - available and new technologies

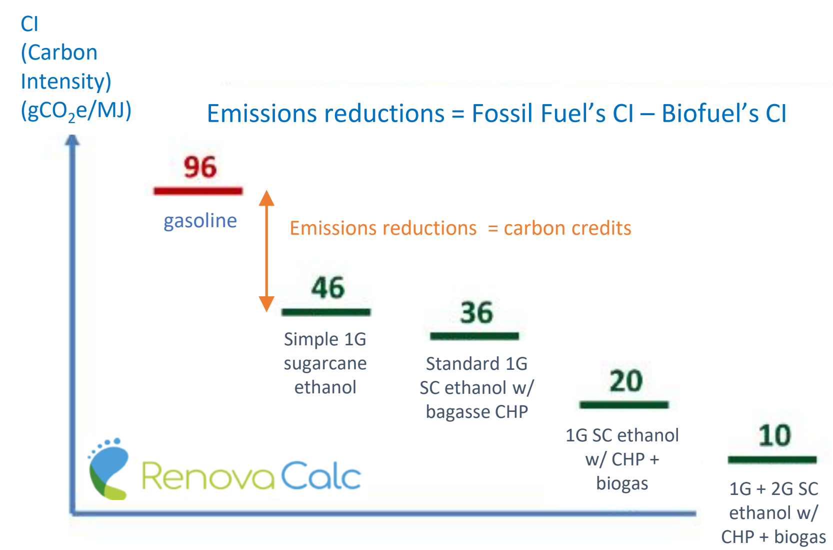
Brazilian commitments at COP 21

RenovaBio

Carbon credits for biofuels based on lifecycle emissions reductions vs a fossil fuel

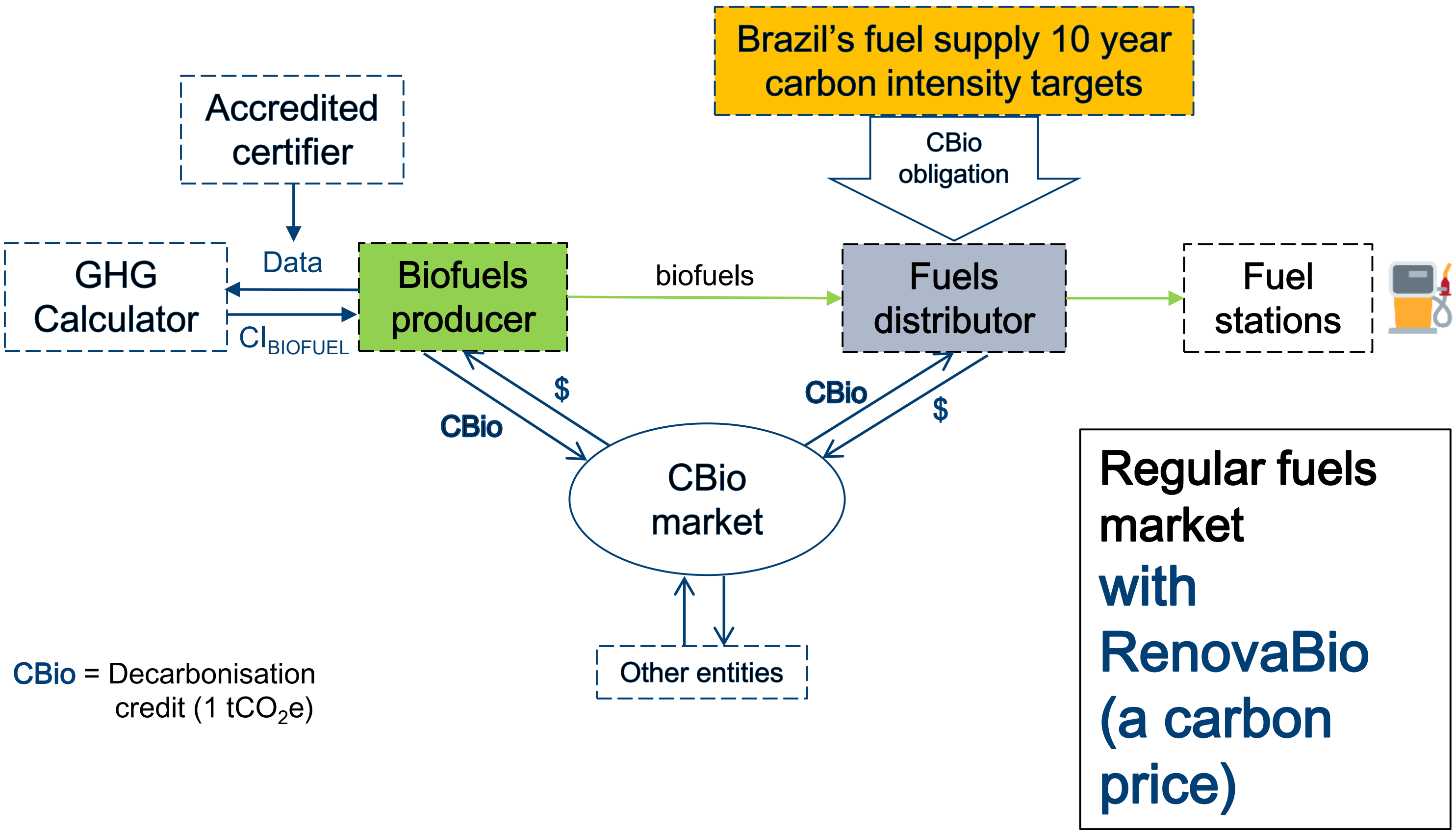
Credits purchased by fuel distributors based on CI reduction targets for the fuel supply

All biofuels: Ethanol, biodiesel, biomethane, HEFA-aviation, ...



2020 – new Project proposals at RCGI/FAPESP/SHELL – BECCS perspectives and impacts on RenovaBio

Regular fuels market


Brazil's fuel supply 10 year carbon intensity targets
CBio obligation
Accredited certifier
Data
GHG Calculator
$CI_{BIOFUEL}$
Biofuels producer
biofuels
Fuels distributor
Fuel stations
$
CBio
CBio
$
CBio market
Other entities
CBio = Decarbonisation credit (1 tCO_2e)
Regular fuels market
with RenovaBio (a carbon price)

IEE USP

GRUPO DE PESQUISA EM BIOENERGIA
Universidade de São Paulo | Instituto de Energia e Ambiente

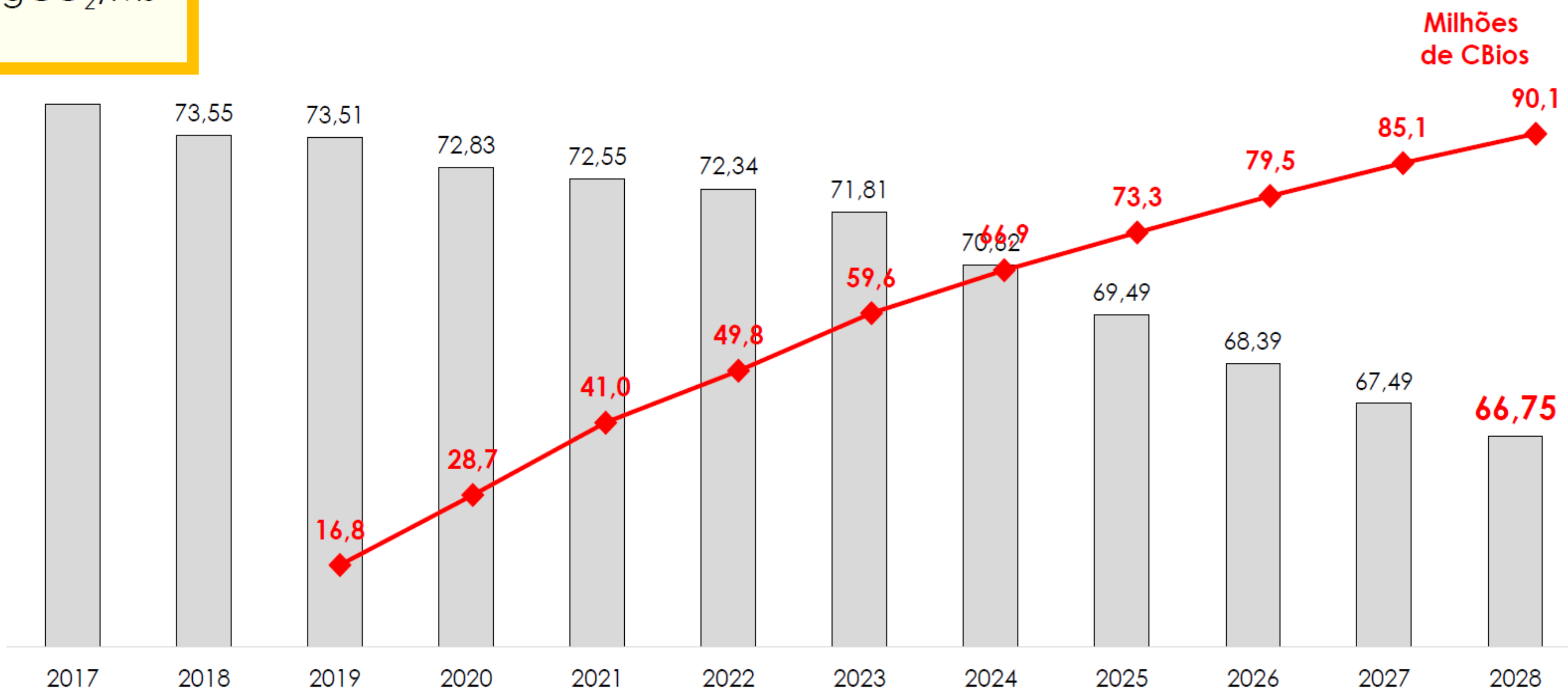
RenovaBio

- **Metas compulsórias**

Definido na meta

~74,25
gCO_2/MJ

Meta de redução da Intensidade de Carbono (IC) da matriz de combustíveis do Brasil (g CO_2/ MJ) – Resolução CNPE N° 05/2018



Fonte: UNICA

RenovaBio

• Metas compulsórias de descarbonização (três maiores)

Código do Agente Regulado	CNPJ	Razão Social	Somatório das Emissões (tCO2 equivalente)	Participação de Mercado (%)	Meta Individual 2019 (CBIO)	(8/365) * (Meta Individual 2019) (CBIO)
1033337122	33.337.122/0001-27	IPIRANGA PRODUTOS DE PETRÓLEO S.A	47.672.760,02	20,65%	3.469.106	76.035
5034274233	34.274.233/0001-02	PETROBRAS DISTRIBUIDORA S.A.	65.866.372,46	28,53%	4.793.039	105.053
1033453598	33.453.598/0001-23	RAIZEN COMBUSTÍVEIS S.A.	40.360.619,61	17,48%	2.937.008	64.373

Total de emissões 230.867.088 t CO2 eq

Total – Metas individuais (CBIO) 16.800.000

Total – Metas individuais (8/365) 368.230 CBIO, conforme Res CNPE N15 (http://www.in.gov.br/web/dou/-/despacho-n-585-de-26-de-julho-de-2019-207468076)

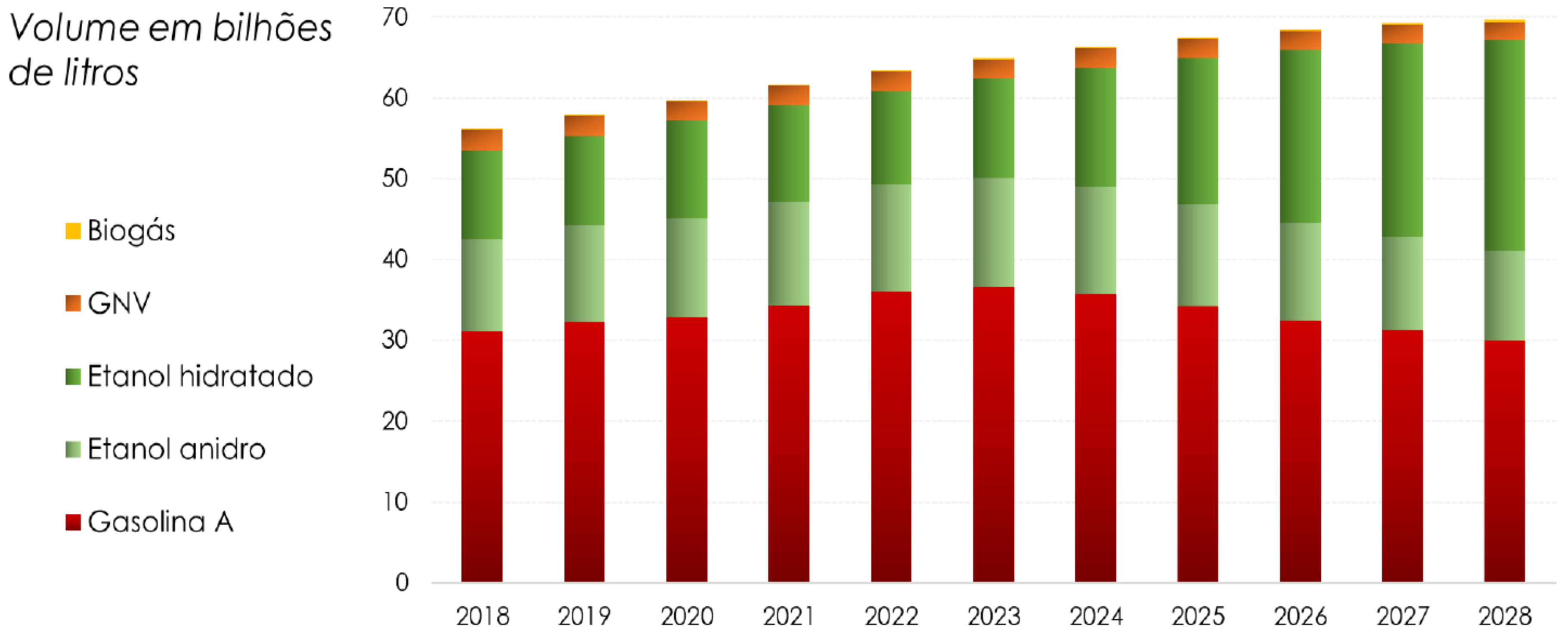
Resolução CNPE Nº 15 DE 24/06/2019 - Art. 3º Excepcionalmente, o distribuidor de combustíveis poderá comprovar sua meta individual do ano de 2019, com vigência a partir do dia 24 de dezembro, em quantidade proporcional ao número de dias de sua vigência, isto é, observada a fração 8/365, cumulativamente com sua meta individual referente ao ano de 2020.

Fonte: ANP - http://www.anp.gov.br/producao-de-biocombustiveis/renovabio/metas-individuais-compulsorias-reducao

RenovaBio

- **Projeções de Ciclo Otto** (gasolina C + etanol + GNV)

Estimativa divulgada pelo Comitê RenovaBio, em consulta pública do Ministério de Minas e Energia



	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Etanol anidro	11,5	11,9	12,2	12,7	13,3	13,5	13,2	12,7	12,0	11,6	11,1
Etanol hidratado	15,2	15,4	16,7	16,6	16,0	17,0	20,4	25,0	29,7	33,1	36,1
Etanol total	26,7	27,3	28,9	29,3	29,3	30,5	33,6	37,7	41,7	44,7	47,2

Fonte: UNICA

GRUPO DE PESQUISA EM BIOENERGIA
Universidade de São Paulo | Instituto de Energia e Ambiente

Efeitos COVID-19 – redução das metas do Renovabio

MINISTÉRIO DE MINAS E ENERGIA
Minas e Energia

ACESSO À INFORMAÇÃO | ALTO CONTRASTE | VLIBRAS

Projetos Covid-19 Login

Buscar no portal

Home / Comunicação / Todas as Notícias / Metas de Descarbonização do RenovaBio

Imprimir

O MINISTÉRIO

Metas de Descarbonização do RenovaBio

publicado: 26/09/2020 13:04, última modificação: 26/09/2020 13:47

Recomendar 0

http://www.mme.gov.br/todas-as-noticias/-/asset_publisher/pdAS9IcdBICN/content/nota-a-imprensa-metas-de-descarbonizacao-do-renovabio

Impacts of COVID pandemic on biofuels*

- Impacts of COVID on fuels’ consumption
- Two challenges:
  - Huge decrease in transportation fuel demand
  - Low oil prices
- Huge impacts on biofuel sector
- To be discussed in this presentation

* COELHO, S. T. How bleak is the future for Brazil´s biofuels sector? Latin America Advisor - Energy Advisor. Washington, DC, USA, p.1 - 6, 2020. https://www.thedialogue.org/energy-advisor/

Impacts of COVID pandemic on biofuels*

- ↓ demand for fuels and ↓ oil prices: huge impact on biofuels
- In Brazil:
  - Ethanol demand ↓ by 50% (UNICA)
  - Ethanol prices ↓ by 35% (from 2.0 BRL down to 1.3 BRL)
  - Main difficulty is ethanol storage, as cane must be crushed
  - Only large groups have relevant storage capacity
  - Sugar production is an option only for industries with flexible process

* COELHO, S. T. How bleak is the future for Brazil´s biofuels sector? Latin America Advisor - Energy Advisor. Washington, DC, USA, p.1 - 6, 2020. https://www.thedialogue.org/energy-advisor/

Impacts of COVID on biofuels in Brazil (2020)*

- Main difficulty: to store ethanol since all mills must crush the cane
- Large groups (Raizen and Sao Martinho) can afford to **store** the ethanol produced
- Average storage capacity is 48.8%**
- Option to produce sugar: an option for industries with flexible process. But several mills produce only ethanol (distilleries). No option for sugar production.

- **2020 Federal Government reduced CBIOs targets by 50%**

*** COELHO, S. T. How bleak is the future for Brazil´s biofuels sector? Latin America Advisor - Energy Advisor. Washington, DC, USA, p.1 - 6, 2020. https://www.thedialogue.org/energy-advisor/**

** https://projetos.pecege.com/

Biocombustíveis – benefícios (pos Covid)

- Geração de emprego e renda nas zonas rurais (importante em períodos de recessão econômica)
- Segurança energética e sustentavel
- Menores impactos ambientais locais (redução nas emissões de particulados
- Reducao nas emissões de GEE – mudanças climáticas

- E os incentivos....

Bioenergy Sustainability

BIOENERGY CONTRIBUTING TO ACHIEVE SUSTAINABLE DEVELOPMENT GOALS

- Established in 2015 at the United Nations
- Each goal has specific targets to be achieved over the next 15 years (2030)

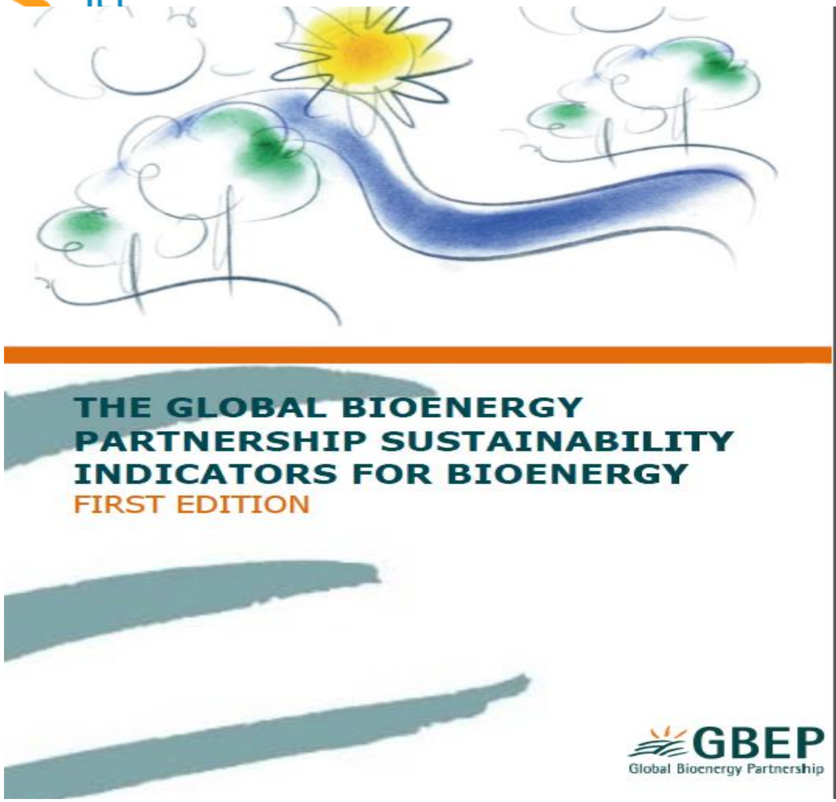
Bioenergy and Sustainable Development

- Reduce greenhouse gas emissions (including in some instances where other opportunities are limited).
- Improve energy security through enhancing diversity of energy supply and reducing the exposure to fluctuating global energy markets.
- Provide economic opportunities including jobs and income for rural economies.
- Complement efforts to improve waste management and air and water quality.
- Help improve modern energy access for some of the 2.7 billion people who lack it (both for heating, cooking and electricity).

IEA, 2017 – Bioenergy Technology Roadmap

Estudos recentes

- Mauricio Roberto Cherubin, ESALQ/USP, 2016. Soil quality response to land-use change for sugarcane expansion in Brazil (Premio 2017)
- Jose Goldemberg, Suani Coelho, Patricia Guardabassi, Plinio Nastari. The Brazilian Experience with Biofuels. Encyclopedia of Sustainability. Springer. 2017
- Ana Cristina Guimarães Donke. Avaliação do desempenho ambiental e energético na produção de etanol decana, milho e sorgo em uma unidade integrada pela abordagem de ciclo de vida. Dissertação de mestrado. PPGE/IEE/USP. 2016.
- Goldemberg, J., **Coelho, S.** (2019). Sustainability and Environmental Impacts of Sugarcane Biofuels. In Khan, M.T., Khan, I.A. (eds.) Sugarcane Biofuels Status, Potential, and Prospects of the Sweet Crop to Fuel the World. Springer. DOI: 10.1007/978-3-030-18597-8_18.



GLOBAL BIOENERGY PARTNERSHIP/FAO
www.globalbioenergy.org

PILLARS GBEP's work on sustainability indicators was developed under the following three pillars, noting interlinkages between them:		
Environmental	**Social**	**Economic**
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Three GBEP Sustainability Pillars

1. Environmental Sustainability

2. Social Sustainability

3. Economic Sustainability

www.globalbioenergy.org

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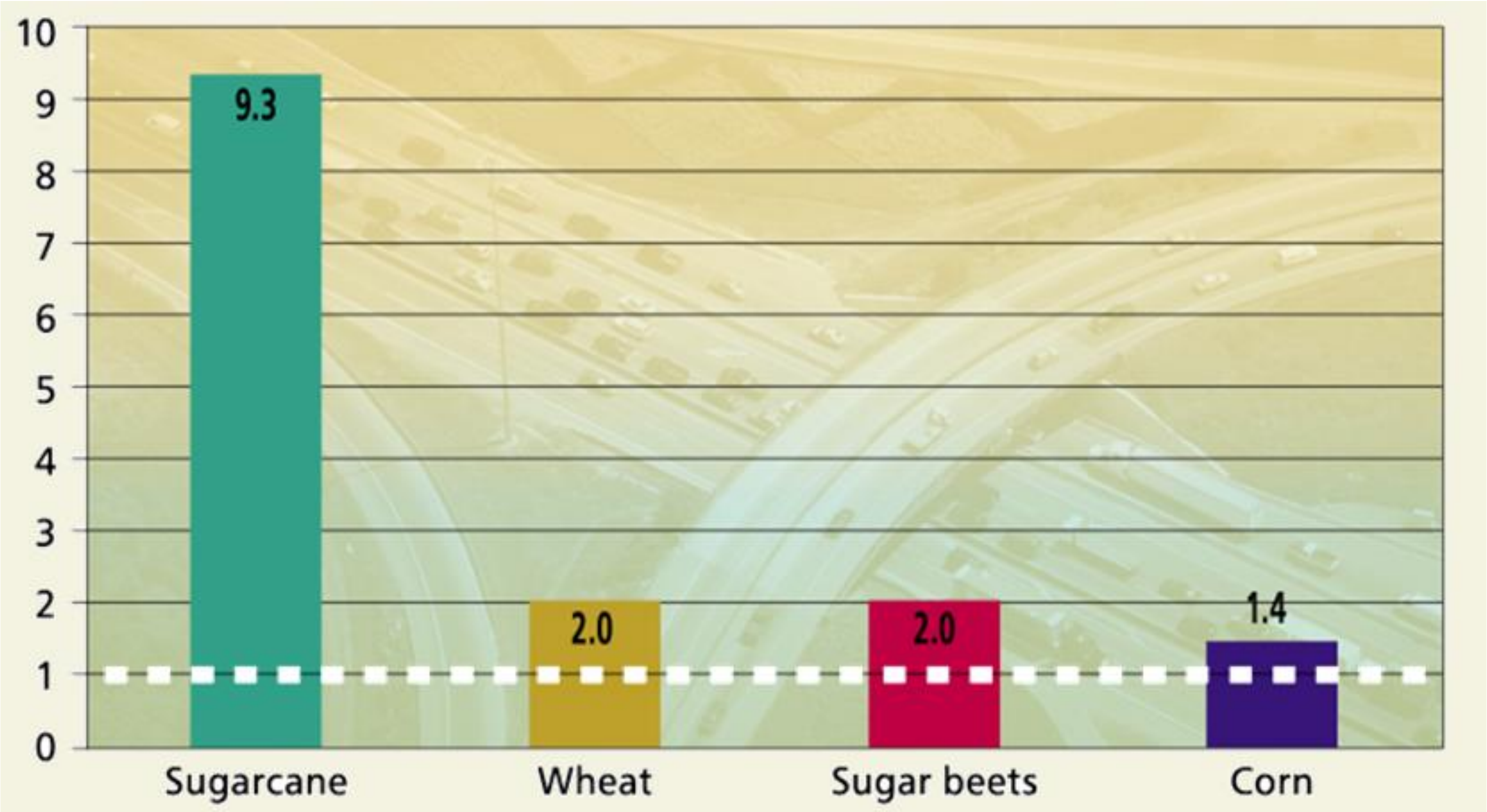
Ethanol Energy Balance for Different Crops

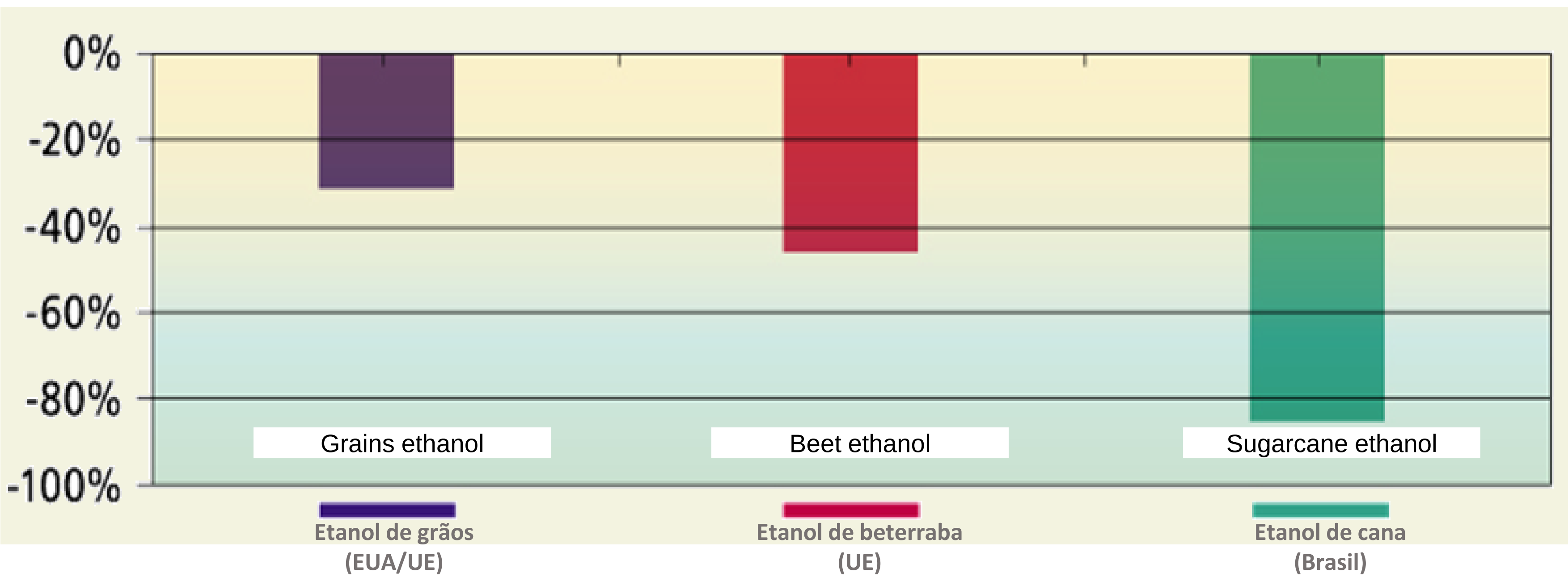


Source: World Watch Institute (2006) e Macedo et al. (2008).
Elaboration: UNICA

Ethanol Energy Balance from Sugarcane

Reduction of GHG emissions

- Ethanol from sugarcane reduces GHG emissions by 90%, to replace gasoline



Source: IEA – International Energy Agency (2004). Elaboration: UNICA.

GHG emissions avoided with gasoline replacement

Feedstock	Avoided emissions
Sugarcane	61% to 82%
Corn	-30% to 38%
Wheat	19% to 47%
Sugar Beet	35% to 56%
Cassava	63%
Lignocellulosic residues*	66.5% to 73%

- UNICA (2010) - including iLUC - sugarcane ethanol has a reduction of GHG emissions of 73-82% compared with gasoline, on a 30- or 100-year time horizon, respectively.	- EPA's calculations - sugarcane ethanol from Brazil reduces GHG emissions compared to gasoline by 61%, using a 30-year payback for iLUC emissions

http://english.unica.com.br/news/38990375920334398749/epa-reaffirms-sugarcane-biofuel-is-advanced-renewable-fuel-with-61-por-cento-less-emissions-than-gasoline/

* In theory – technology under development

Sources: Dai et al, 2006; EBAMM, 2005; IEA, 2004; Macedo et al, 2007 e Nguyen et al, 2007

Land use in Brazil - 2017

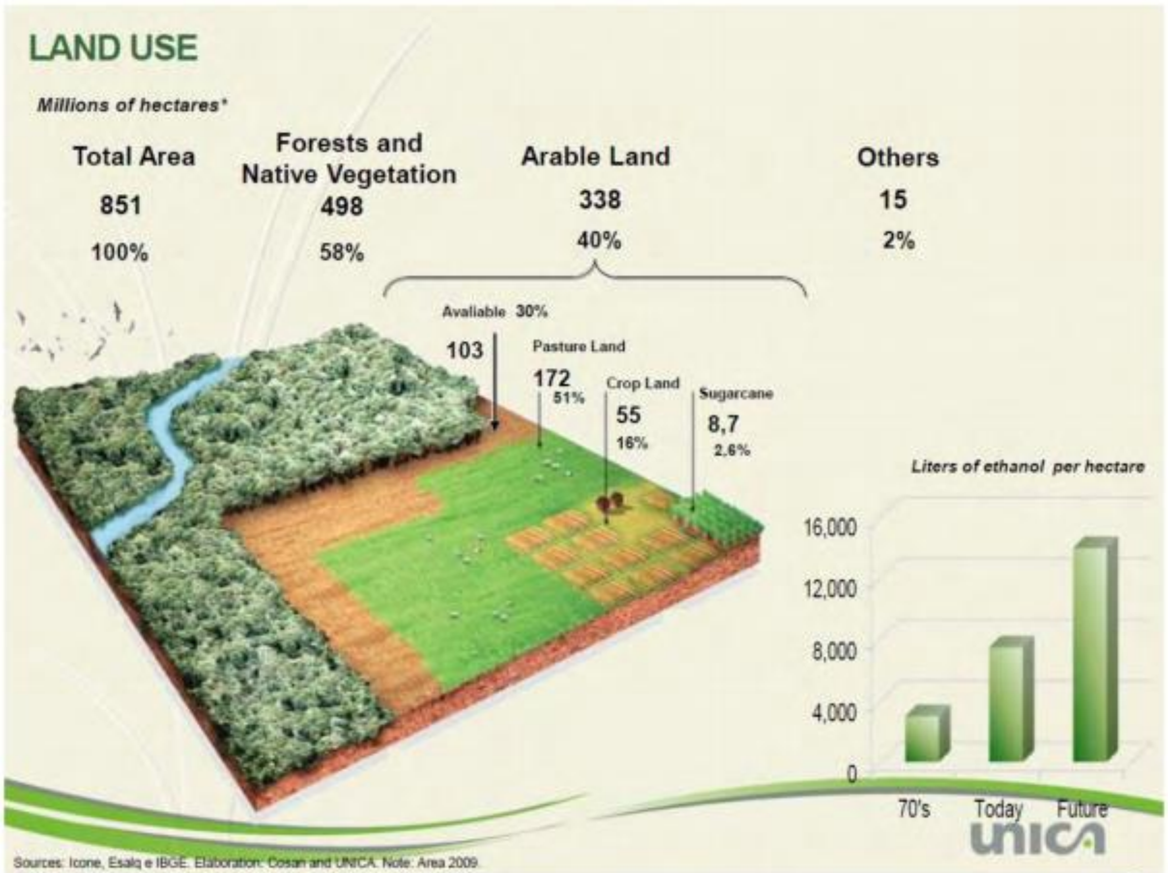
Millions of hectares	
Brazil	851
Arable land	354,8
1. Total cultivated area	**84,2**
Soy	33,2
Corn	15,2
Grains	10,1
Citrus	9,3
Sugar cane	8,6
Forestry production	7,8
2. Grasslands	**168,0**
3. Available area (degraded)	**140,0**

Ethanol = 4.3 MM ha

cattle

Source: (Escobar, 2016). Based on (IBGE, 2016); (FEAP, 2016); (FUNDECITRUS, 2016); (CONAB, 2016a); (CONAB, 2016b).

Impact on Biodiversity and Ecosystem



Evolution of the pasture area in the State of Sao Paulo-2001/2008

	2001	2002	2003	2004	2005	2006	2007	2008
Cattle (million heads)	13,15	13,46	13,76	13,77	14,07	13,75	12,20	11,95
Pastures (million hectares)	10,29	10,10	10,11	10,12	10,01	9,71	9,12	7,64
Density (**heads of cattle**/ha)	1,28	1,33	1,36	1,36	1,41	1,42	1,34	1,56

Trend for more intensive use

Source: Secretaria de Estado de Agricultura. Elaboration: GBIO/IEE/USP

Scenarios for more intensive pastures in Brazil

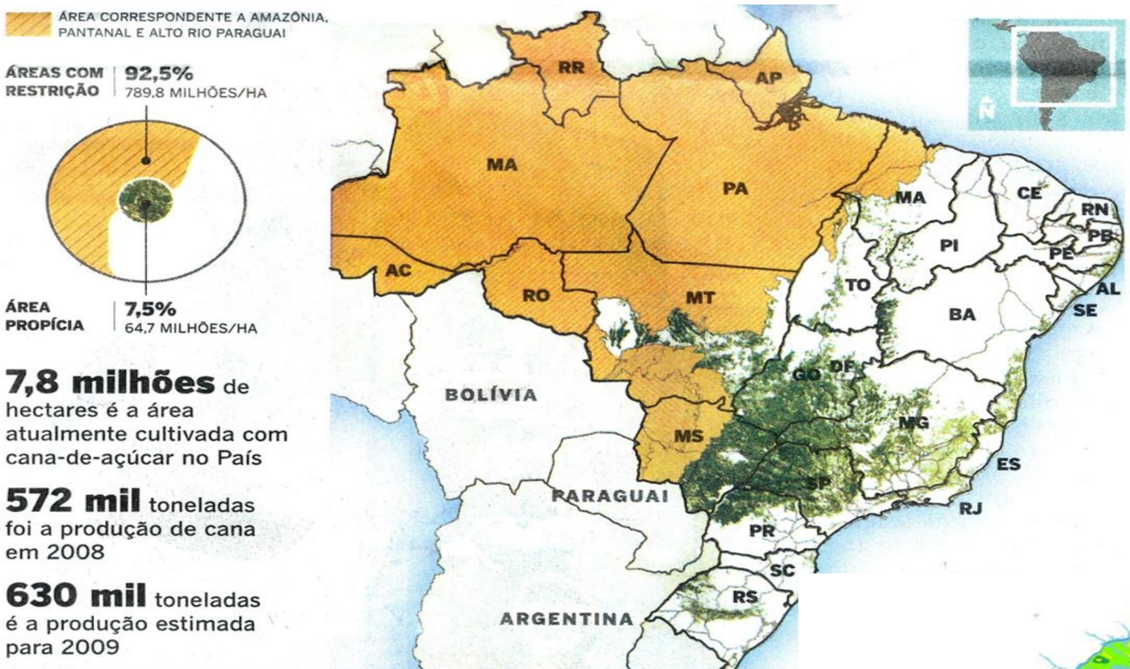
Current situation		
Area	**Heats of cattle**	**Density (Heats of cattle/ha)**
172 million hectares	169 million	0,98
Prospects		
108 million hectares	169 million heats of cattle	1,56 (SP - 2008)

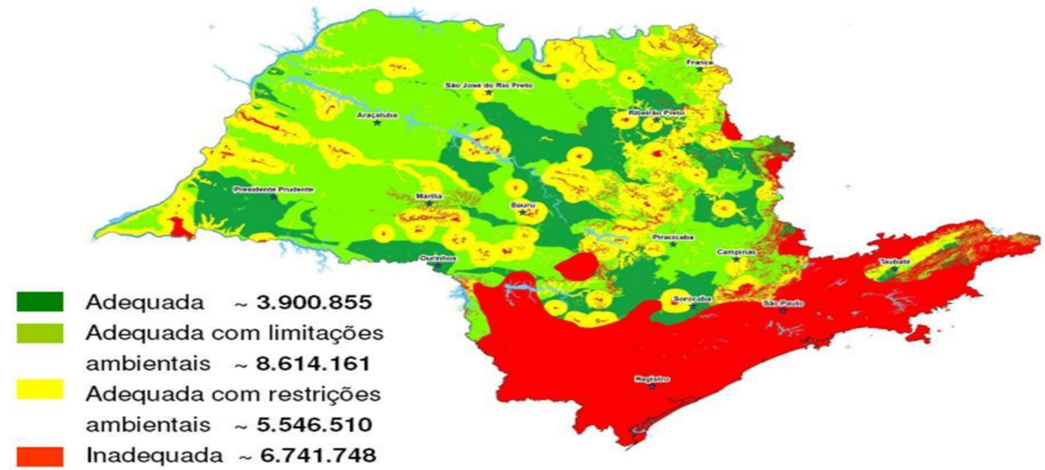
64 million hectares will be available !

→ Biofuels

→ Food

Brazil/Sao Paulo - Agro-ecological Zoning of Sugarcane





Water use in sugarcane ethanol

- Irrigation: most of the sugarcane produced in Brazil does not need irrigation.

  Industrial processes:

  - reduction on water consumption (SP):

    1997: 5 m3 /t sugarcane

    2004: 1.83 m3/t sugarcane

    2013/14: 1,18 m3/tc

    2014/15: 1 m3/tc (**some mills 0.7**)

  - 2015 – Cetesb - 0.85 m3/t sugarcane

  - water recycling
  - high efficiency in water treatment: 98%
  - sugarcane washing process replaced by dry cleaning
  - mechanical harvesting of green cane – no cleaning

Agrochemical consumption – sugarcane vs corn ethanol

	Sugarcane		Corn	
	consumption/ha	consumption/m³	consumption/ha	consumption/m³
Ethanol production(m³)	8,1		4,2	
N (kg)	25	3,1	140	33,7
P (kg)	37	4,6	100	24,1
K (kg)	60	7,4	110	26,5
Limestone (kg)	600	74,5	500	120,5
Herbicide (liters)	2,6	0,3	13	3,1
Insecticide (liters)	0,1	0	2,2	0,5
Ant Insecticide (kg)	-	-	0,5	0,1
Nematicide (liters)	1,2	0,1	-	-
Total	726,2	90,2	865,7	208,5

Sources: Agrianual (2008); Fancelli e Dourado Neto (2006)

RESOLUÇÃO CONAMA no 382, de 26 de dezembro de 2006 Publicada no DOU nº 1, de 2 de janeiro de 2007, Seção 1, página 131-137 Estabelece os limites máximos de emissão de poluentes atmosféricos para fontes fixas.

Caldeiras a bagaço

Potência térmica nominal (MW)	MO(1)	Nox(1) (como NO_2)
Menor que 10	280	N.A.
Entre 10 e 75	230	350
Maior que 75	200	350

(1)os resultados devem ser expressos na unidade de concentração mg/Nm3, em base seca e corrigidos a 8% de oxigênio.
N.A. - Não aplicável.

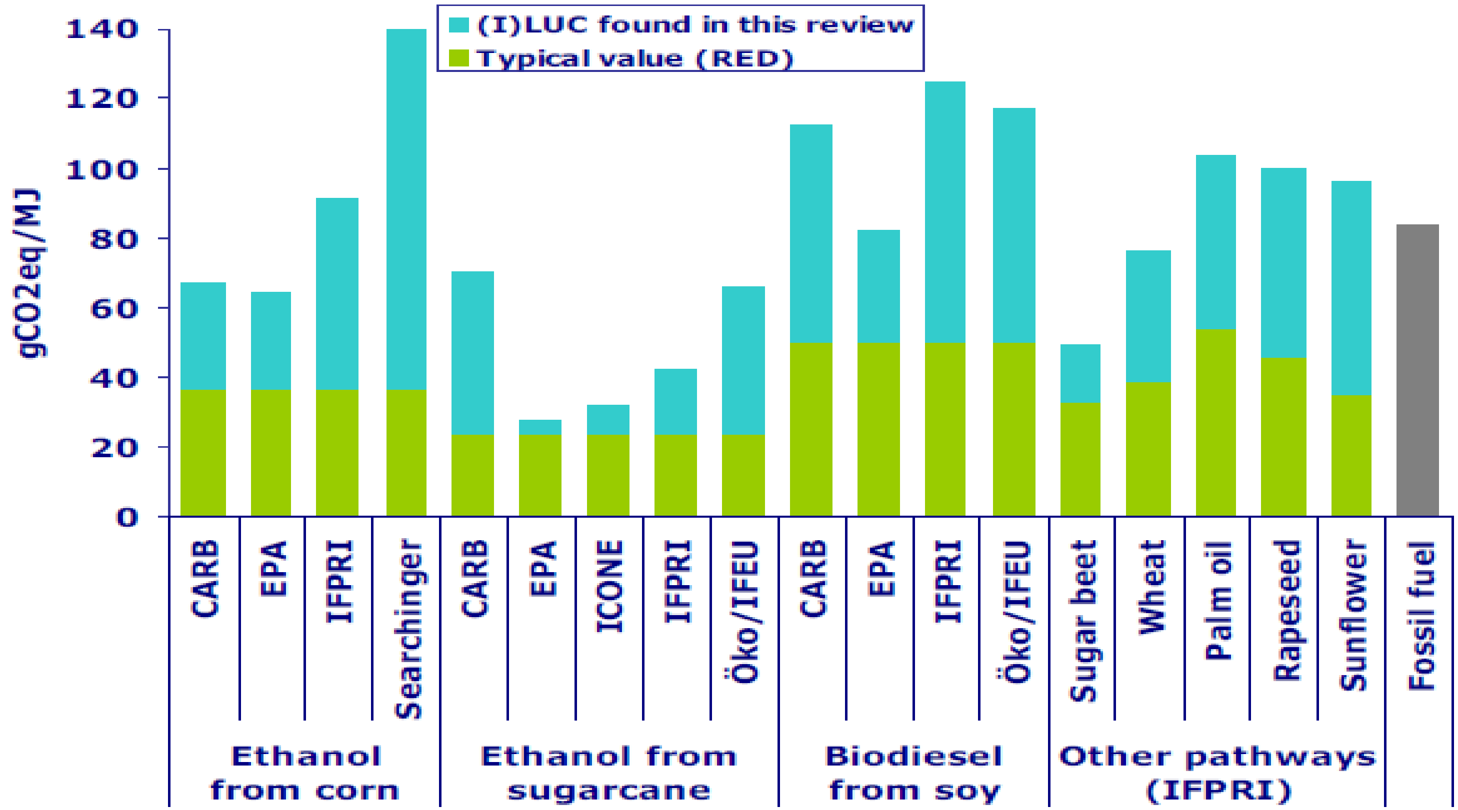


Figure 2 - 2 Graphical representation of the emissions caused by (I)LUC, direct and indirect land use change, for different biofuel pathways and different studies. For reference, typical non-land-use change emissions for the different pathways and a fossil reference from the EU Renewable Energy Directive (RED) have been added.

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2. **Social Sustainability**

3. Economic Sustainability

N.A.

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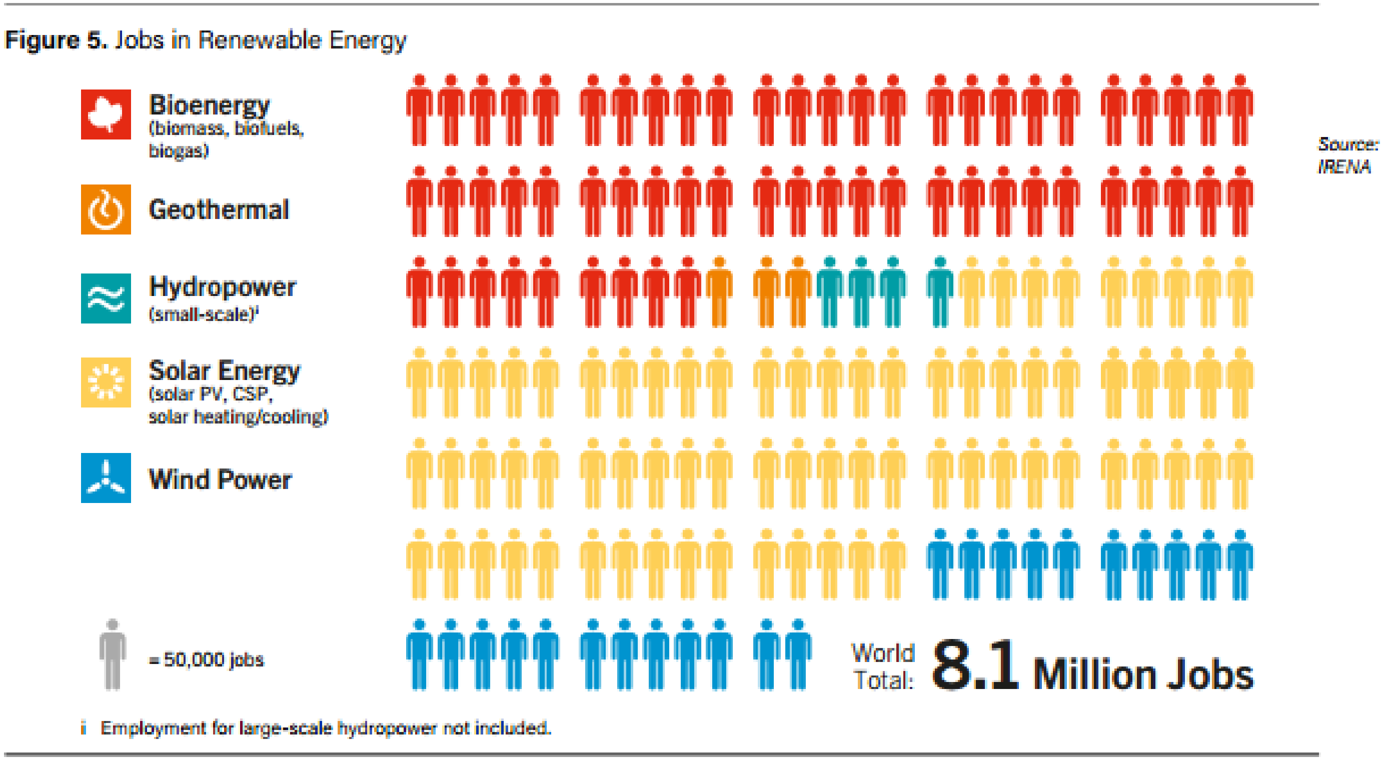
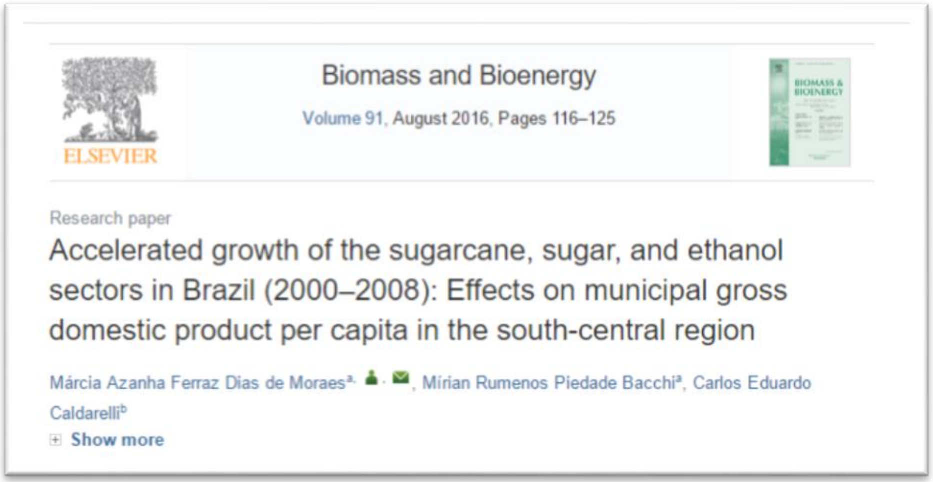
Bioenergy and Jobs Creation



REN21, 2018


ELSEVIER

Biomass and Bioenergy

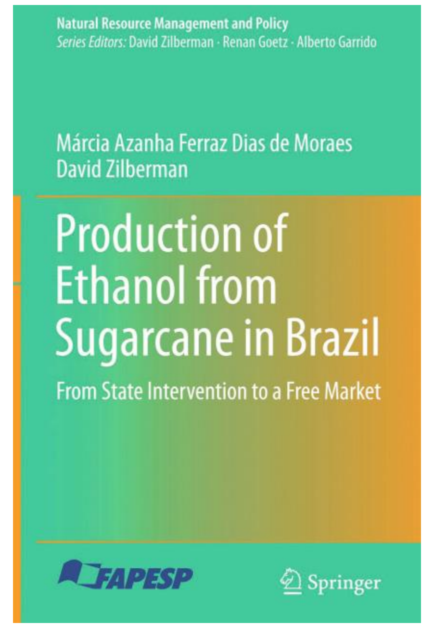
Volume 91, August 2016, Pages 116–125

Research paper

Accelerated growth of the sugarcane, sugar, and ethanol sectors in Brazil (2000–2008): Effects on municipal gross domestic product per capita in the south-central region

Márcia Azanha Ferraz Dias de Moraes[a], Mírian Rumenos Piedade Bacchi[a], Carlos Eduardo Caldarelli[b]

Show more



*Research funded by the *Fundação de Amparo à Pesquisa do Estado de São Paulo* (FAPESP, São Paulo Research Foundation; Grant no. 2013/14005-4)

Project main results

GeMt ESALQ-USP

ESALQ

Effect on municipalities:

- 10 percentual points increase in the relation sugarcane área/temporary crops: municipal GDP increase U$ 76 per capita
- Industrial plant installation: increase on average municipal GDP (anual per capita)
  - U$ 1098 in the municipality where the mill is installed
  - U$ 457 in each of the 15 municipalities around the mill
- Timeline: 10 years after mil installation / sugarcane areas, anual municipal GDP increase:
  - U$ 1028 in the municipality where the mill is installed
  - U$ 324 in each of the 15 municipalities around the mil

Source: Azanha, M. et al

SOCIAL PILLAR

10. Price and supply of a national food basket

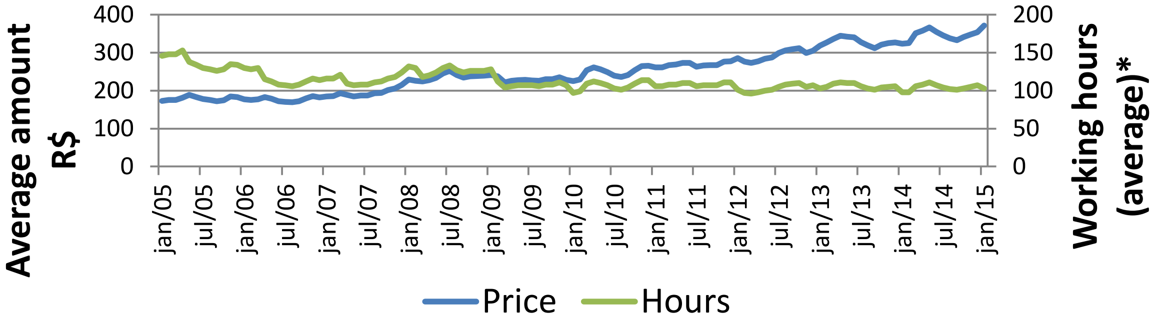
Summary of main agricultural products produced in São Paulo and their representativeness in gross value of agricultural production in São Paulo

	Average 2002/11
SUGARCANE	**53,35%**
ORANGE	14,29%
CORN	5,28%
ROUNDWOOD	4,56%
SOYBEAN	3,69%
COFFEE	3,54%
POTATO	2,26%
TOMATO	1,91%
BEAN	1,84%

Source: CEPEA/USP(2015)

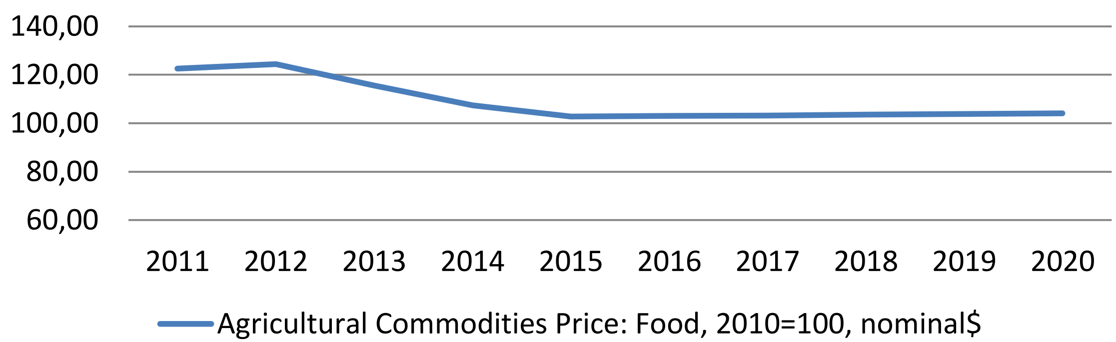
10. Price and supply of a national food basket

Real value of the food basket in the State of São Paulo (DIEESE 2015)

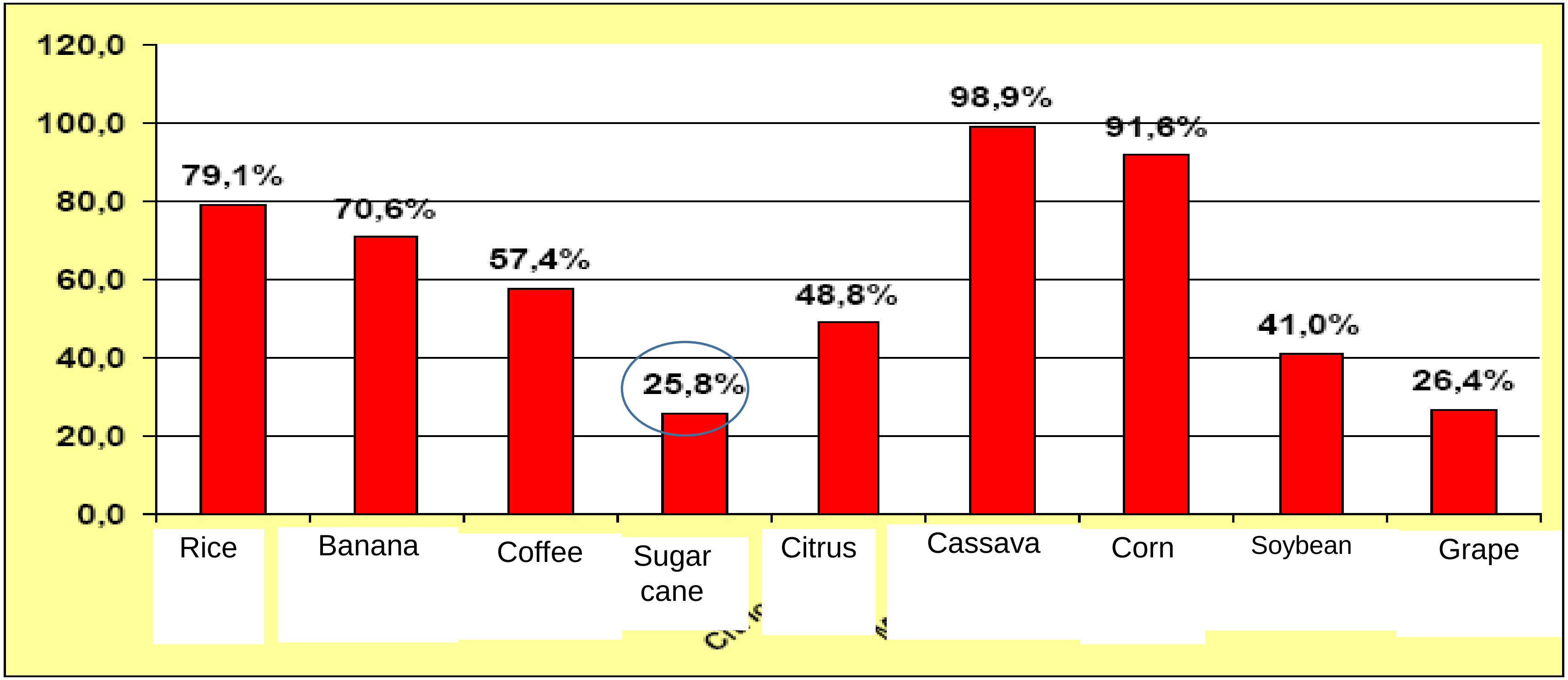


Forecasting of agricultural food commodity prices

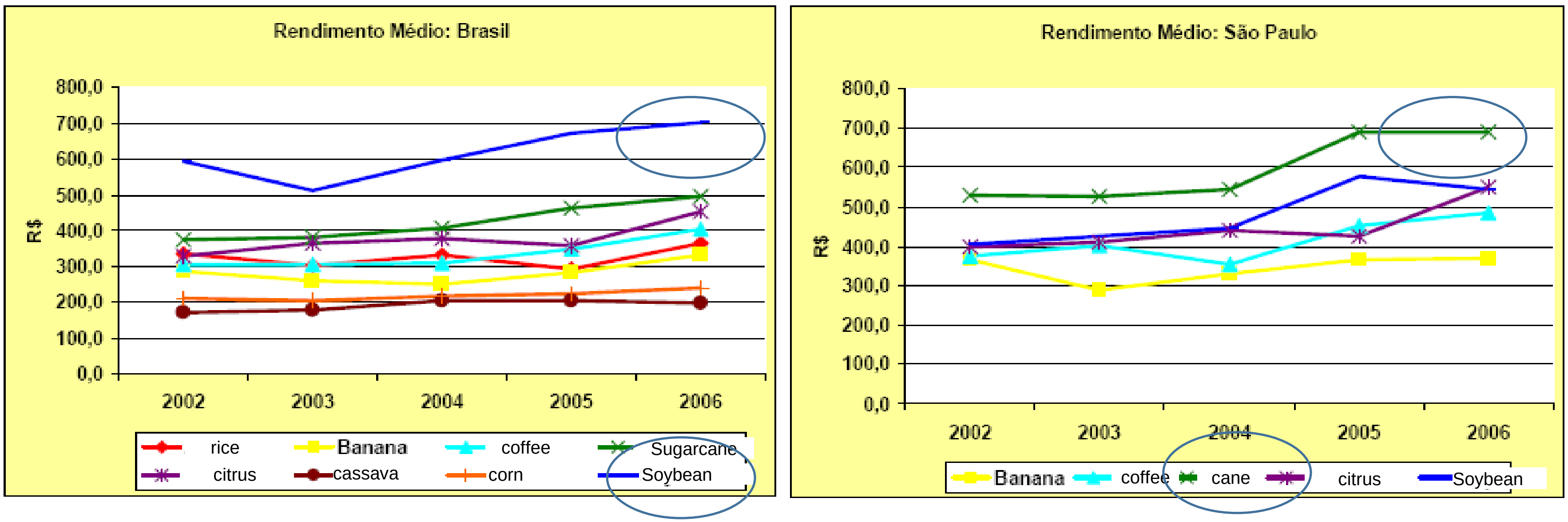
Source:World Bank (2015)



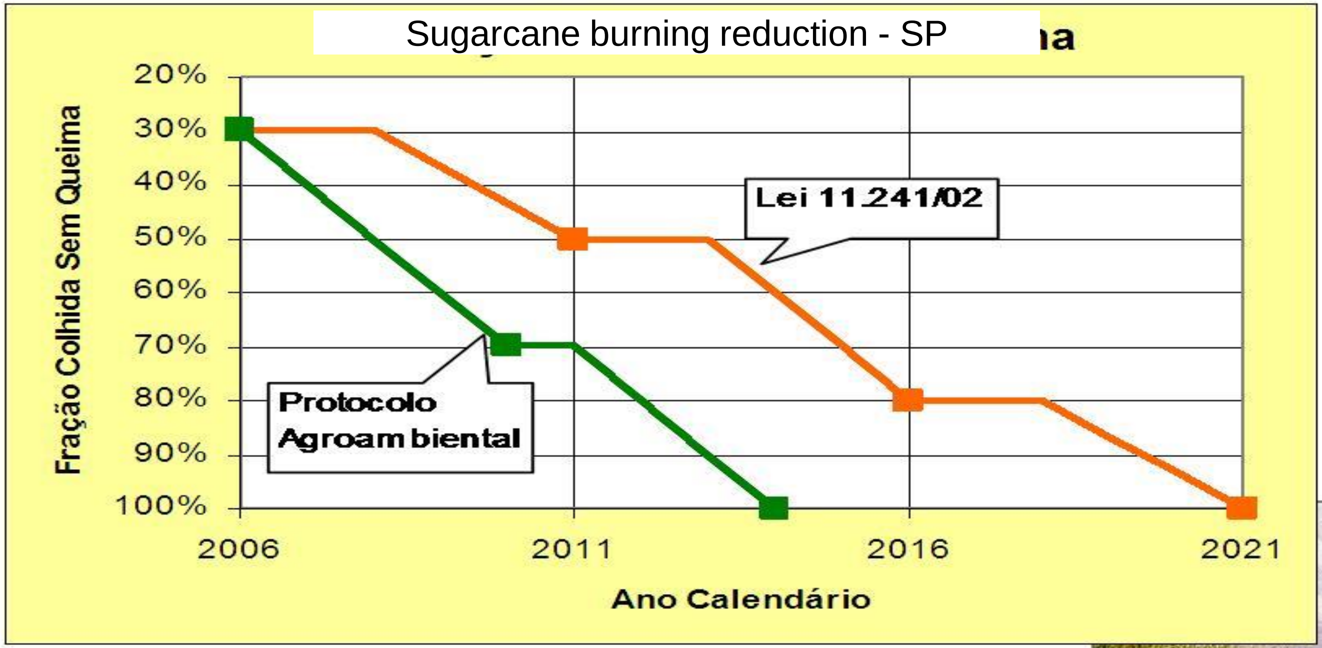
Percentage of informal jobs in agricultural sector.
Brazil, 2006



Evolution of the average income of employees in several crops. Brazil and São Paulo, 2002-2006 (BRL - August 2007)



Phase out of sugarcane burning



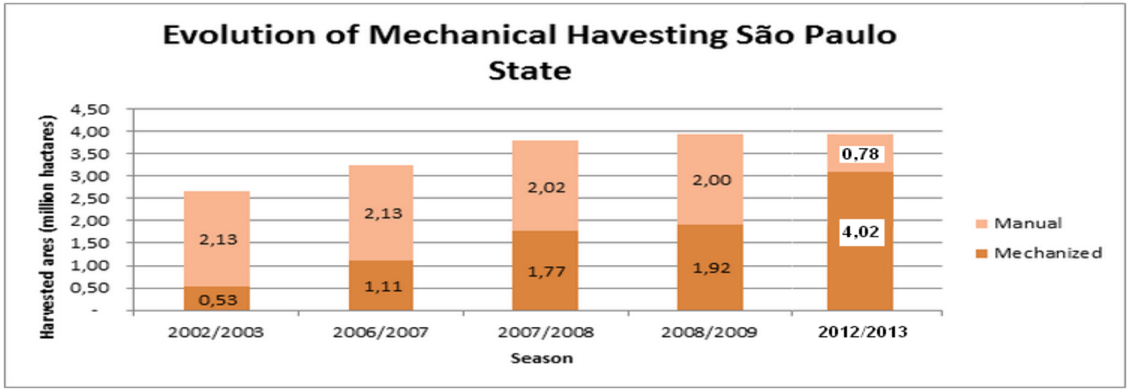


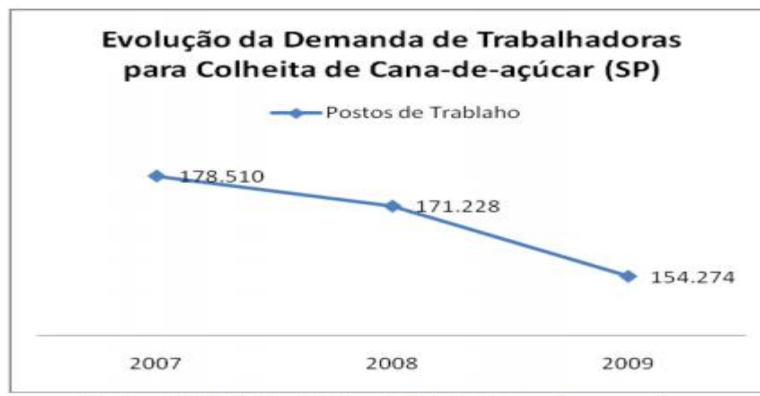
Fig. 3.12 Mechanical harvesting of green cane. (Photo courtesy of Agricef Soluções Tecnologicas Para Agricultura Ltda, Brazil; reprinted with permission)

Mechanical harvesting in São Paulo:

May 2013: 72.6% of the areas that could be mechanized
were harvested without burning, corresponding to 3.38 million hectares, against
34.2% in 2006

Source: Coelho, S. T., Guardabassi, P. "Ethanol". In: B. D. Solomon, R. Bailis (eds.), *Sustainable Development of Biofuels in Latin America and the Caribbean,* DOI 10.1007/978-1-4614-9275-7_3 © Springer Science+Business Media NewYork

Evolution of jobs for manual harvesting of sugarcane in São Paulo



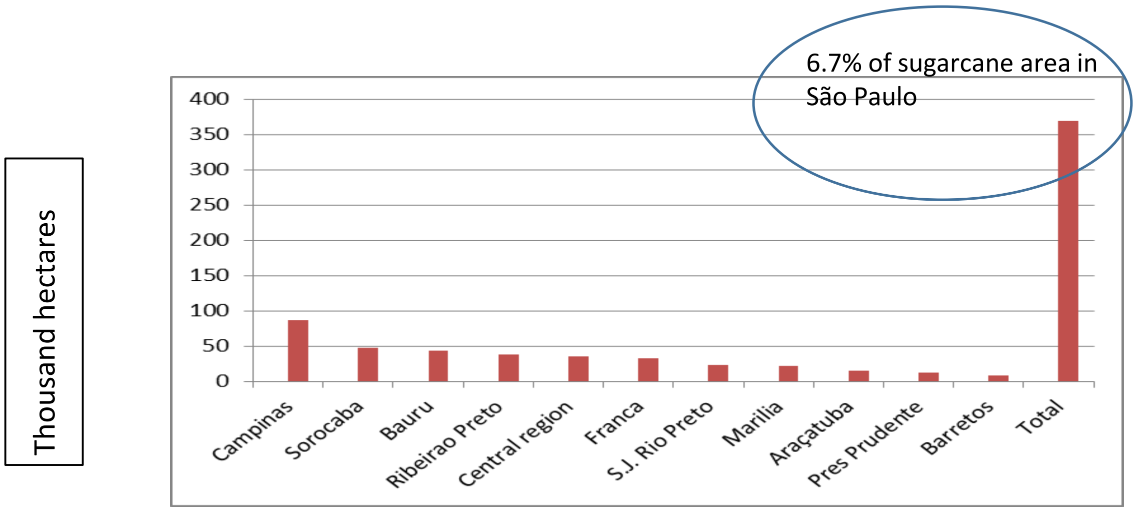
Dados: TEM (Ministério do Trabalho e Emprego)

21. Social impacts from mechanized harvesting

Elimination of sugarcane crops in the state of São Paulo

Slopes higher than 12%

Other crops?
Or
New harvesting machines for slopes higher than 12%?



Source: Embrapa/FIESP (2014)

Fig. 3.12 Mechanical harvesting of green cane. (Photo courtesy of Agricef Soluções Tecnologicas Para Agricultura Ltda, Brazil; reprinted with permission)

21. Requalification - social impacts from mechanized harvesting (desk review)

- Reduction on the number of jobs in compliance with the elimination of burning.
- Since 2007 Unica associates **retrained more than 5,000 people**.
- Requalification program:
  - Unica, Feraesp and companies in the production chain,
  - support of the Interamerican Development Bank (IADB),
  - workers and members of the communities in six regions of São Paulo.
  - **capacity building: drivers, tractors operators and harvesters, other areas (mechanic, electrician and welder); programs for other sectors such as forestry, horticulture, handicrafts, construction, computing, sewing, catering and tourism.**
- ***Renovação* project** : 4,350 workers qualified in 2012/2013 season (http://www.unica.com.br)

Energy access

- Development of economic activities, making energy supply economically sustainable and affordable for the local population.
- **Brazil: surplus of sugarcane-bagasse-based electricity is sold to the interlinked grid and distributed all over the country.**
- **In other DC´s - supply rural households.**

Source: Field visit (S. Coelho) – Cogen for Africa project (2011)

Three GBEP Sustainability Pillars

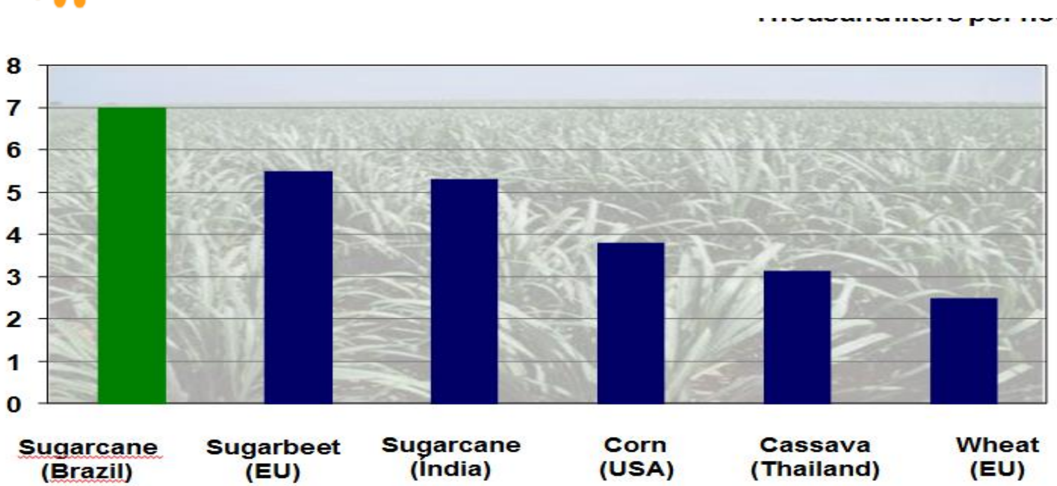
1. Environmental Sustainability

2. Social Sustainability

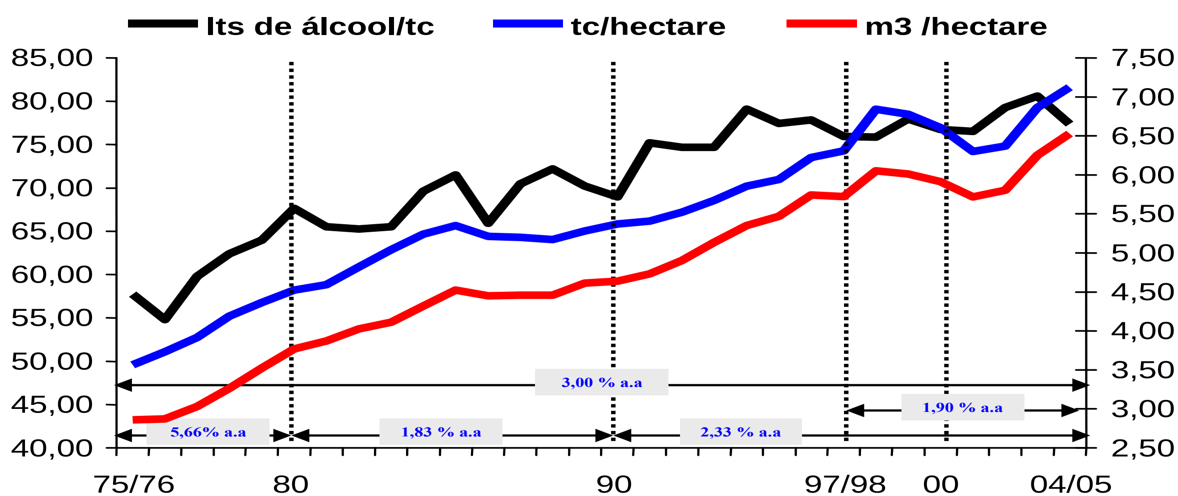
3. **Economic Sustainability**

PILLARS GBEP's work on sustainability indicators was developed under the following three pillars, noting interlinkages between them:		
Environmental	**Social**	**Economic**
THEMES GBEP considers the following themes relevant, and these guided the development of indicators under these pillars:		
Greenhouse gas emissions, Productive capacity of the land and ecosystems, Air quality, Water availability, use efficiency and quality, Biological diversity, Land-use change, including indirect effects.	Price and supply of a national food basket, Access to land, water and other natural resources, Labour conditions, Rural and social development, Access to energy, Human health and safety.	Resource availability and use efficiencies in bioenergy production, conversion, distribution and end use, Economic development, Economic viability and competitiveness of bioenergy, Access to technology and technological capabilities, Energy security/Diversification of sources and supply, Energy security/Infrastructure and logistics for distribution and use.
INDICATORS		
1. Lifecycle GHG emissions	9. Allocation and tenure of land for new bioenergy production	17. Productivity
2. Soil quality	10. Price and supply of a national food basket	18. Net energy balance
3. Harvest levels of wood resources	11. Change in income	19. Gross value added
4. Emissions of non-GHG air pollutants, including air toxics	12. Jobs in the bioenergy sector	20. Change in consumption of fossil fuels and traditional use of biomass
5. Water use and efficiency	13. Change in unpaid time spent by women and children collecting biomass	21. Training and requalification of the workforce
6. Water quality	14. Bioenergy used to expand access to modern energy services	22. Energy diversity
7. Biological diversity in the landscape	15. Change in mortality and burden of disease attributable to indoor smoke	23. Infrastructure and logistics for distribution of bioenergy
8. Land use and land-use change related to bioenergy feedstock production	16. Incidence of occupational injury, illness and fatalities	24. Capacity and flexibility of use of bioenergy

Ethanol productivity (liters per hectare)

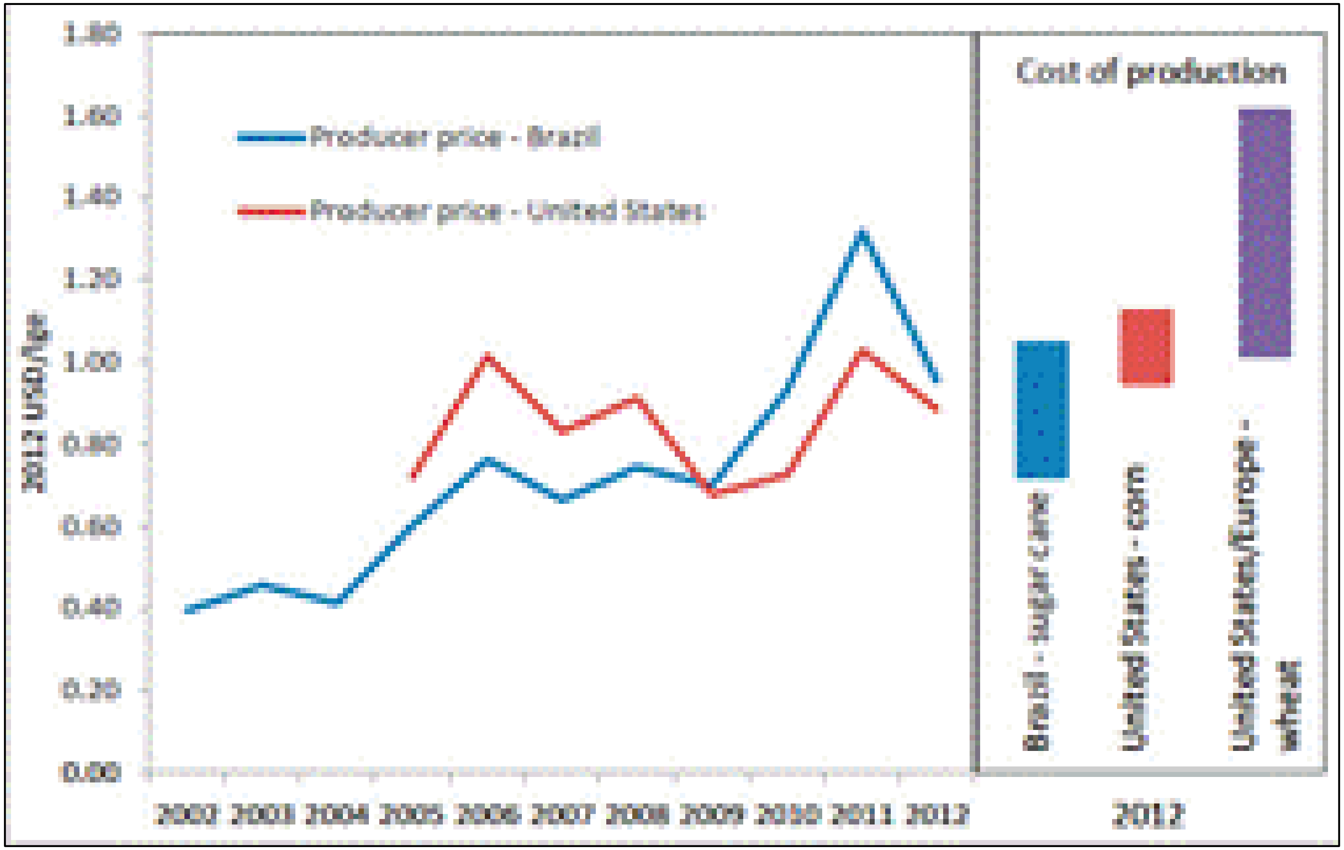


Source: Rodrigues, Unicamp .2005

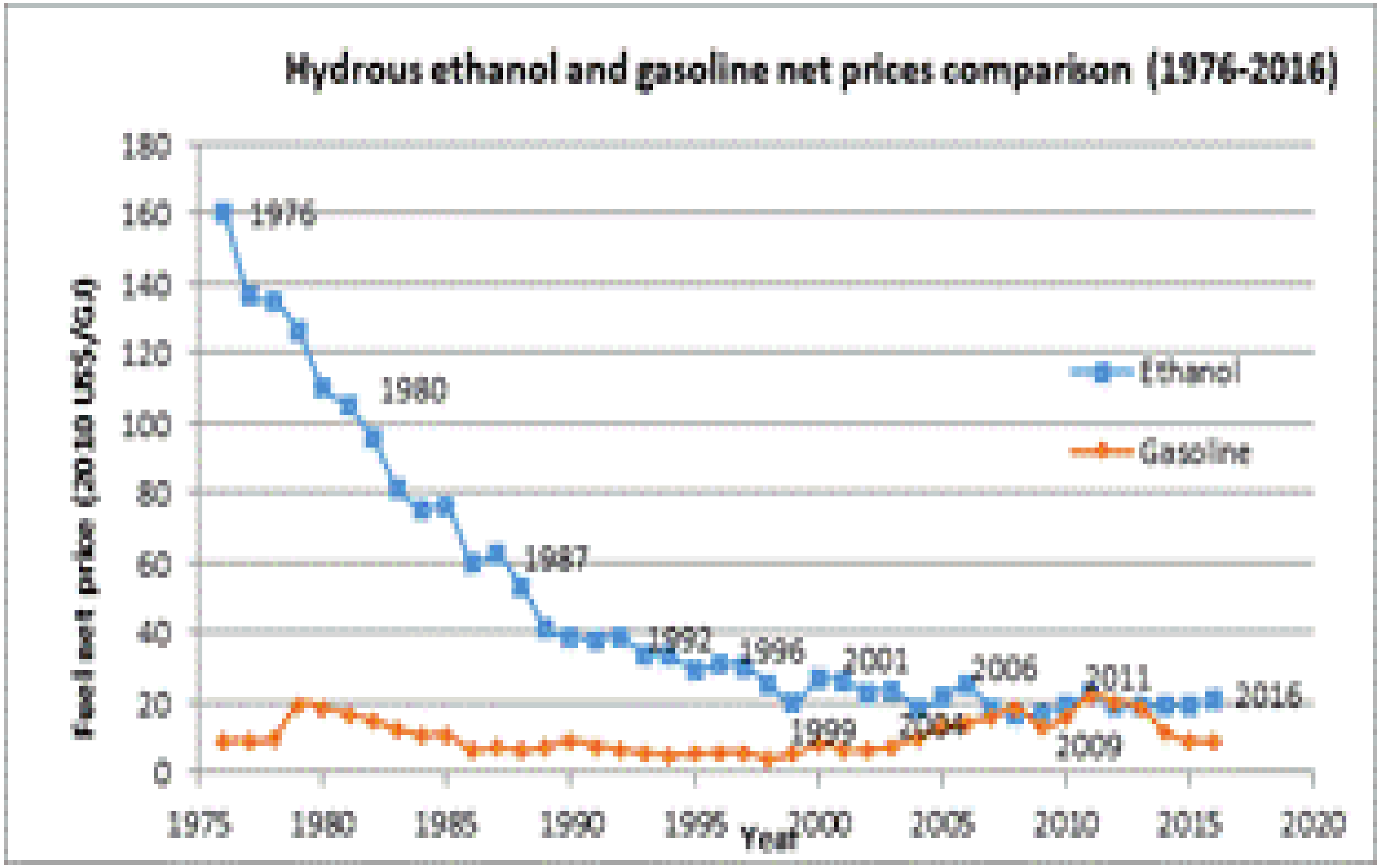


Sugarcane ethanol in Brazil
Growth rate 3.8% per year

Ethanol production costs for different crops IRENA(2013)



Brazil - Hydrous (sugarcane) ethanol and gasoline (net) prices comparison (1976-2016)



Source: J Goldemberg, P Guardabassi (IEE/USP).
Personal Communication (2017)

(SAFRA 2013/2014)

Tabela 1. Indicadores de produtividade agrícola

Descrição	Regiões	
	Tradicional	Expansão
Produtividade (t/ha)	86,55	69,93
Processamento total de cana (t)	2.225.097	2.088.976
ATR cana processada (kg/t)	131,37	132,70
ATR cana fornecedor (kg/t)	134,79	133,29
ATR padrão (kg/t cana)	121,97	121,97
Preço do ATR (R$/kg)	0,4836	0,4681

Fonte CEPEGE/ESALQ/USP, 2015

- **Tradicional** : sub-regiões de Catanduva, Jaú, Piracicaba e Sertãozinho (número amostral de 11 usinas; 14% de moagem total na região, estimada em 290 milhões de ton)
- **Expansão**: sub-regiões de Araçatuba e Assis (6 usinas amostradas; 13% da cana produzida na região, que foi de aproximadamente 123 milhões de ton).

Tabela 2. Indicadores de rendimento industrial

	Tradicional	Expansão
Nível de utilização da capacidade instalada	92,7%	87,0%
Perdas industriais		
Perdas industriais comuns	8,3%	7,0%
Rendimento de fermentação	90,3%	88,3%
Rendimento de destilação	99,6%	99,7%
Produtividade Industrial		
Etanol anidro (L/t cana)	77,1	77,3
Etanol hidratado (L/t cana)	81,2	81,5
Produção eletricidade (KWh/t)	65,95	70,47
Mix Produção		
Etanol	39,7%	42,5%
Anidro	72,8%	22,0%
Hidratado	27,2%	78,0%

(SAFRA 2013/2014)

Tabela 3. Custos de produção de cana de açúcar

DESCRIÇÃO	Tradicional	Expansão
Matéria-prima	**79,52**	**80,15**
COE	59,28	57,95
Cana de fornecedores	27,51	18,56
COE cana própria	31,77	39,39
Depreciações	11,77	15,41
Remuneração do capital e terra	8,48	6,79
Industrial	**26,09**	**26,26**
Operação industrial	13,47	12,82
Deprec.	3,88	4,14
Custo de Capital	8,74	9,31
Administrativo	**9,36**	**7,70**
Custo Total	**114,97**	**114,11**

Fonte: PECEGE/ESALQ/USP, 2015

*Os **custos de produção na região Tradicional superam os custos da região Expansão**, algo não esperado quando são comparados os indicadores agrícolas e industriais de ambas as regiões. A explicação para isso é o **elevado custo da terra na região Tradicional,** que acaba por mais que compensar os ganhos de eficiência obtidos no campo e na baixa ociosidade da indústria (PECEGE/ESALQ/USP, 2015).*

Custos, preços e margens do etanol anidro e hidratado (SAFRA 2013/2014)

	ANIDRO		HIDRATADO	
	Tradicional	Expansão	Tradicional	Expansão
RT+RC	223,31	208,16	211,94	197,56
DEP	203,02	252,78	192,68	239,91
COE	1.054,27	1.018,04	989,70	954,88
COT	1.257,30	1.270,82	1.182,39	1.194,79
CT	1.480,61	1.478,98	1.394,33	1.392,35
Preço	1.342,36	1.367,38	1.226,26	1.220,73
Margem	-9,3%	-7,5%	-12,1%	-12,3%

- Custos Operacionais Efetivos (COE)
- Custos Operacionais Totais (COT)
- Custo Total (CT).
- Custos desembolsáveis: COE.
- COT: COE mais as depreciações.
- CT = COT mais os custos de oportunidade (uso do capital e da terra)

Fonte: PECEGE/ESALQ/USP, 2015

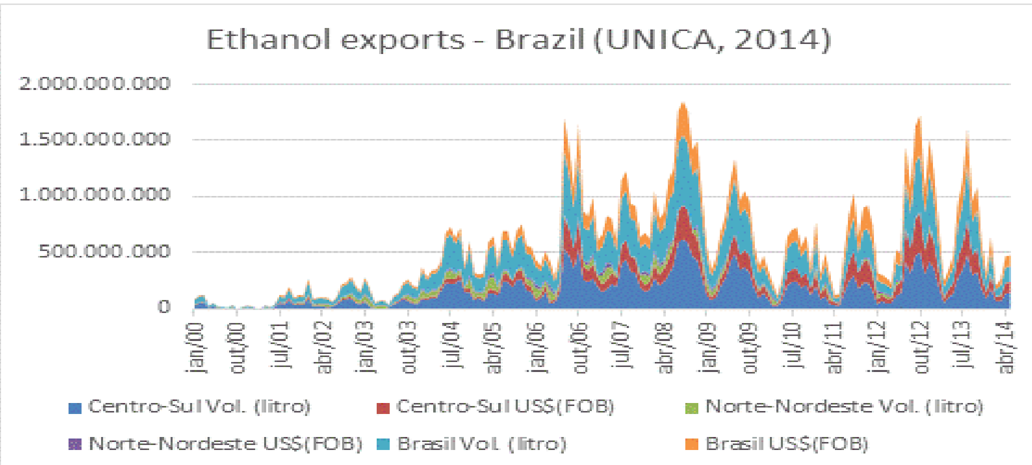
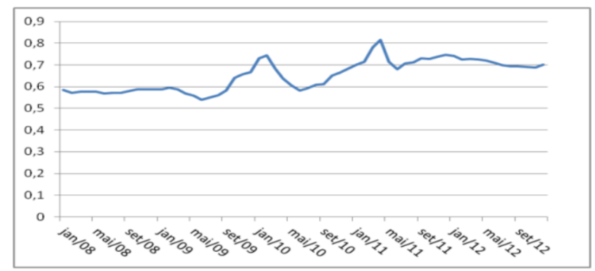
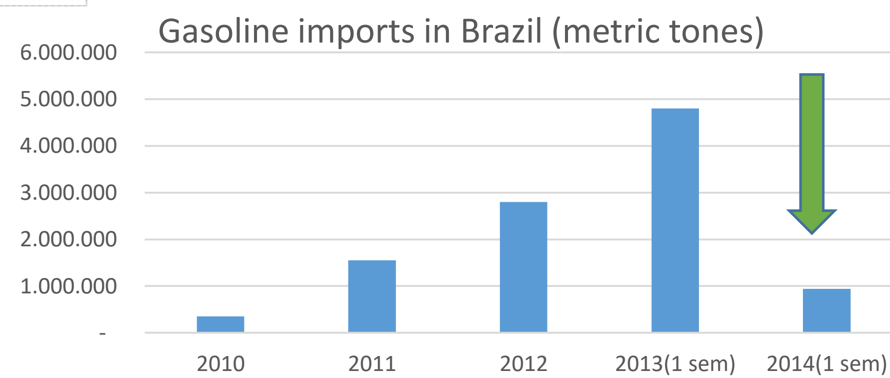


Figura 3 – Preço relativo do etanol hidratado (razão preço etanol/preço gasolina C)

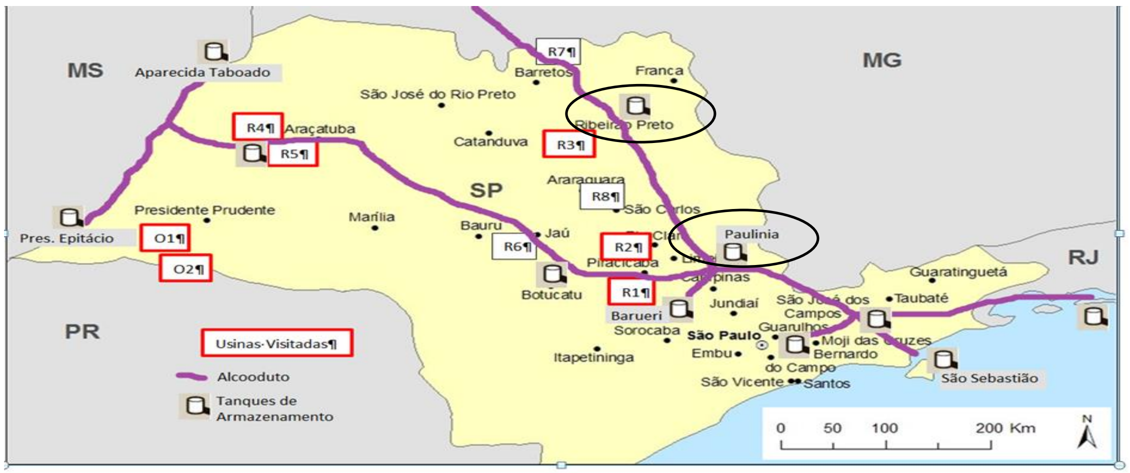


Fonte: ANP

Increase on ethanol blend to gasoline 25% in 2014



23. Infrastructure and logistic
Logistic - Ethanol pipelines in São Paulo



O1 – Fazenda Conquista do Pontal, Mirante do Paranapanema. Odebrecht
O2 – Fazenda Alcídia, Teodoro Sampaio. Odebrecht.
R1 – Fazenda Bom Retiro, Capivari. Raizen.
R2 – Costa Pinto, Piracicaba. Raizen.
R3 – Bonfim, Guariba. Raizen.
R4 – Gaza, Andradina. Raizen.
R5 – Univalem, Valparaiso. Raizen.
R6 – Fazenda Santo Antônio, Dois Córregos. Raizen.
R7 – Junqueira, Igarapava, Raizen.
R8 – Serra, Ibate. Raizen.

- Logum Co. was formed as a joint venture of Copersucar, Cosan, Petrobras, ETH Bioenergia, and other independent producers.
- To construct and operate a dedicated ethanol pipeline (21.8 billion litters per year when it becomes full operation).
- First section - linking Ribeirao Preto to Paulinia (later on to Ilha d'Água terminal in Rio de Janeiro) - commissioned in March 2013.

Source: Goldemberg, Coelho, Nastari et al. Production and Supply Logistics of Sugarcane as an Energy Feedstock. In Wang, L. (ed), "Sustainable Bioenergy Production", 2013.

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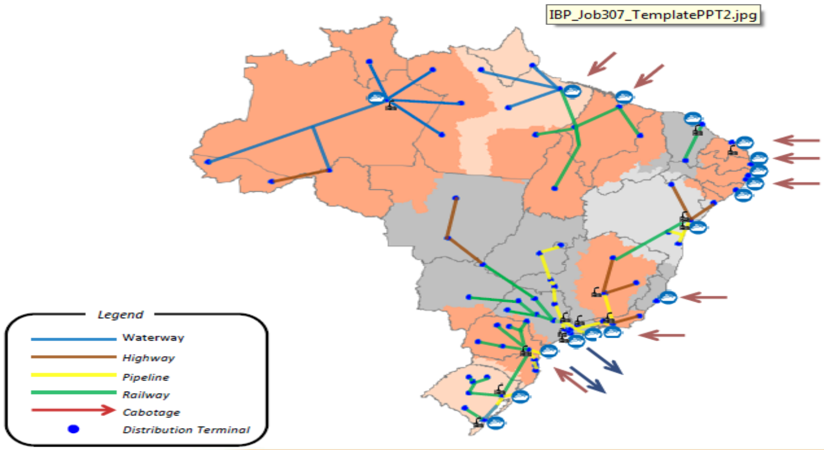
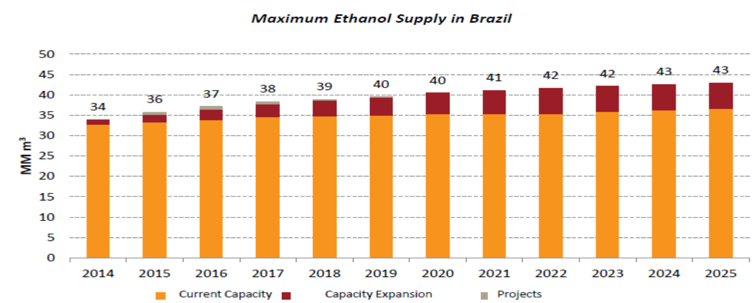
Analysis of Infrastructure for Fuel Distribution in Brazil: Investiments 2020 - 2025

Marcus D'Elia

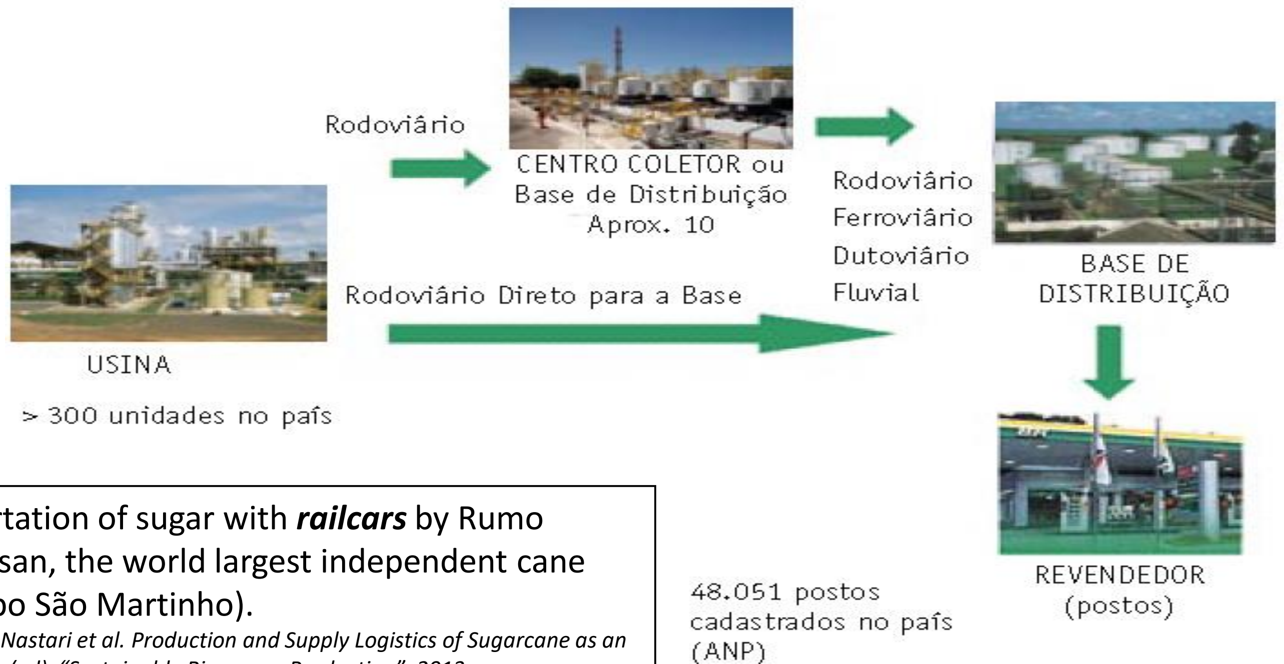
Current Infrastructure



Otto Cycle Supply Ethanol



23. Infrastructure and logistic
Ethanol distribution system



Sao Paulo: Transportation of sugar with ***railcars*** by Rumo Logística (Grupo Cosan, the world largest independent cane processor, and Grupo São Martinho).

Source: Goldemberg, Coelho, Nastari et al. Production and Supply Logistics of Sugarcane as an Energy Feedstock. In Wang, L. (ed), "Sustainable Bioenergy Production", 2013.

LOGISTICA
Exportação de etanol
(UNICA, 2015)

Exportações anuais de etanol por local de embarque (mil litros)
Fonte: UNICA a partir de dados da SECEX.

Local de embarque	2012	2013
PORTO DE SANTOS	2.447.990	2.519.845
PORTO DE PARANAGUA	431.055	287.173
MACEIO - PORTO	120.420	35.781
RECIFE - PORTO (SUAPE)	34.198	16.083
SAO LUIS - PORTO	34.413	9.801
VITORIA - PORTO	14.762	9.844
JOAO PESSOA - PORTO (CABEDELO)	5.116	6.467
RIO DE JANEIRO - PORTO	51	11.111
JAGUARAO - RODOVIA	4.811	3.432
FOZ DO IGUACU - RODOVIA	2.060	1.598
CHUI	1.347	1.106
URUGUAIANA - RODOVIA	1.122	423
SAO FRANCISCO DO SUL - PORTO	815	217
PONTA PORA - RODOVIA	85	91
PONTA PORA - AEROPORTO	51	37
PORTO DE RIO GRANDE	0,41	0
BAGE	0,39	0
CAMPINAS - AEROPORTO	0	0,23
RIO DE JANEIRO - AEROPORTO	0,01	0
MANAUS - AEROPORTO	0	0,00
SAO PAULO - AEROPORTO	0,00	0
CENTRO-SUL	**2.904.150**	**2.834.877**
NORTE-NORDESTE	**194.148**	**68.133**
TOTAL	**3.098.298**	**2.903.010**

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Methodology for impacts allocation
Study case for an average sugarcane mill

SUGARCANE CRUSHED		300	tc/h
SUGAR PRODUCTION		17	t/h
ETHANOL PRODUCTION	anhydrous	7375	litters/h
	hydrous	7375	litters/h
ELECTRICITY TO THE GRID		40	kWh/tc

To be adapted to each mill

Allocation methods - examples

- Energy basis

Sugar		3865	kcal/kg
Anhydrous ethanol		6750	LHV (kcal/l)
Hydrous ethanol		6300	LHV (kcal/l)

- Economic basis (average prices in September 2014)

Sugar		1,0367	R$/kg
Hydrous ethanol		1,1683	R$/litter
Anhydrous ethanol		1,3366	R$/litter
Electricity		197	R$/MWh (marginal expansion cost)

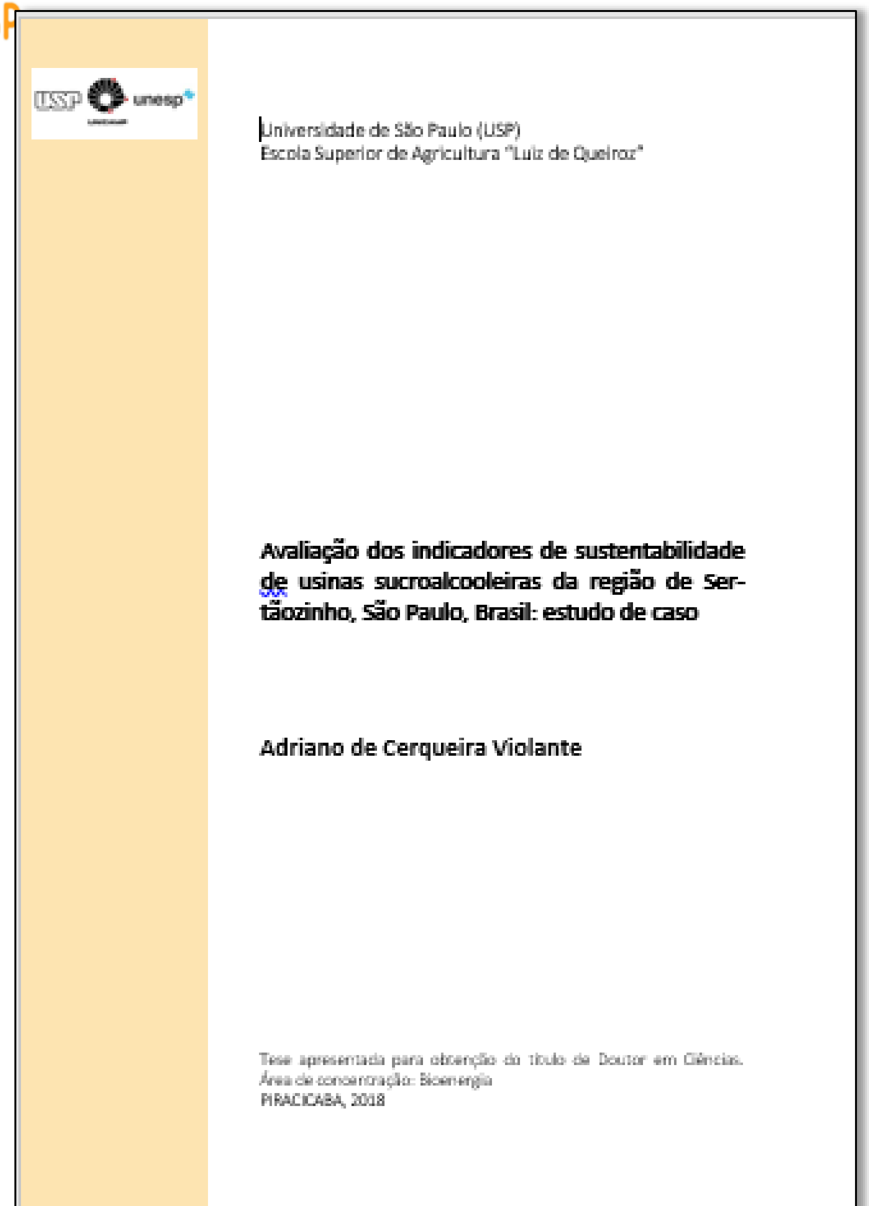
Preliminary Results

- Allocation – energy basis

	Energy equivalent		% in energy equivalent
Sugar	64.416.667	kcal eq/season	38%
Ethanol	96.243.750	kcal eq/season	56%
Electricity	10.320.000	kcal eq/season	6%
Total	170.980.417	kcal eq/season	100%

- Allocation – economic basis

	Economic equivalent		Porcentage
Sugar	88.191.493,06	R$/season	45%
Ethanol	94.292.524,74	R$/season	48%
Electricity	12.066.250,00	R$/season	6%
Total	194.550.267,80	R$/season	100%


Universidade de São Paulo (USP)
Escola Superior de Agricultura "Luiz de Queiroz"

Avaliação dos indicadores de sustentabilidade de usinas sucroalcooleiras da região de Sertãozinho, São Paulo, Brasil: estudo de caso

Adriano de Cerqueira Violante

Tese apresentada para obtenção do título de Doutor em Ciências. Área de concentração: Bioenergia
PIRACICABA, 2018

EVALUATION OF SUSTAINABILITY INDICATORS FOR SUGARCANE MILLS IN SERTAOZINHO REGION, SÃO PAULO, BRAZIL: A CASE STUDY

Adriano C. Violante - 2018

PhD Thesis – PhD Program on Bioenergy – USP – UNICAMP - UNESP

GRUPO DE PESQUISA EM BIOENERGIA
Universidade de São Paulo | Instituto de Energia e Ambiente

UNICAMP

Manuel Moreno Ruiz Poveda
Engenheiro Florestal

Integração do biogás de vinhaça na matriz energética de Ribeirão Preto, Estado de São Paulo

versão revisada de acordo com a resolução CoPGr 6018 de 2011

Orientadora:
Profª. Drª. **SUANI TEIXEIRA COELHO**

Tese apresentada para obtenção do título de Doutor em Ciências. Área de concentração: Bioenergia

Piracicaba
2019

Universidade de São Paulo
Programa de Educação Continuada – Escola Politécnica da USP
Especialização em Energias Renovaveis, Geração Distribuída e Eficiência Energética.

Gisele Pulz Fernandes

Potencial Energético da Vinhaça para Geração de Biogás - Estudo de Caso em Usina sucroenergética no estado de Goiás

São Paulo
2017

MARCELO AKIRA MIZUTANI

ANALISE TÉCNICA E ECONÔMICA DO USO DA VINHAÇA PARA A PRODUÇÃO DE BIOGÁS

Monografia apresentada à Escola Politécnica da Universidade de São Paulo para obtenção do título de Especialista em Energias Renováveis, Geração Distribuída e Eficiência Energética.

São Paulo
2017

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Caio Luca Joppert - MSc candidate

Technical and Economic viability of the energetic shift of sugarcane bagasse using biogas produced from vinasse

How much bagasse is it possible to displace towards 2G ethanol production using biogas produced from vinasse, without causing an impact on the mill energy matrix?

Biocombustíveis no Brasil: Fundamentos, Aplicações e Perspectivas - Carlos Augusto G. Perlingeiro
ANP - **SYNERGIA EDITORA**

CASSINI, S. T. ; COELHO, S. T. ; PECORA, V. . Biogás- Biocombustíveis ANP. In: Carlos Augusto G. Perlingeiro. (Org.). Biocombustíveis no Brasil - Fundamentos, Aplicações e Perspectivas. C. Rio de Janeiro: Synergia Editora, 2014, v. 1, p. 136-167

Technologies for biogas and biomethane production and use

- Digital version available at:
  - http://www.iee.usp.br/gbio/
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http://www.iee.usp.br/gbio/?q=noticia/pesquisadores-do-gbio-lan%C3%A7am-livro-sobre-tecnologias-de-produ%C3%A7%C3%A3o-e-uso-de-biog%C3%A1s-e-biometano