# Programa de Pós-Graduação em Energia

# PEN 5014

## Biomassa como Fonte de Energia - Conversão e Utilização

**Prof. Suani Coelho**

**São Paulo, 25 de setembro de 2020**

RESEARCH GROUP ON BIOENERGY

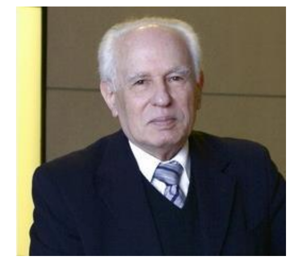
SINCE 1996

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

**Coordination:** Prof. Dr. Suani T. Coelho;
**Special contribution:** Prof. Dr. José Goldemberg

## Research team (2019):

- **Pos doc:**
  *Djalma Ferraz (Imperial College)*
  *Javier Farago Escobar (Harvard University)*
  *Marilin Mariano dos Santos*
  *Vanessa Pecora Garcilasso*
- **PhD students:**
  *Ana Paula Souza*
  *Danilo Perecin (Imperial College)*
  *Fernando Oliveira*
  *João Pacheco*
  *Monica Anater (Utrecht University)*
  *Roberto Sartori*
  *Claudia Treumann*
- **Master students**
- **Two Oxford University students**
- **One PhD student from Colombia**
- **One PhD student from Mexico**



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

IEE USP

**www.iee.usp.br/gbio**

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

CNPq
Conselho Nacional de Desenvolvimento Científico e Tecnológico
CERTIFICADO PELA INSTITUIÇÃO

## Acontece GBio

O GBio participa do Workshop sobre "Política Nacional de Resíduos Sólidos promovido pela FIESP

25/ago/2015

mais

## Atlas de Biomassa

Atlas de Biomassa

O Grupo de Pesquisa em Bioenergia (GBio), criado em 2015, é formado pelo grupo de pesquisadores que anteriormente compunham o CENBIO, o Centro Nacional de Referência em Biomassa.

O Centro Nacional de Referência em Biomassa foi criado em 1996, através de convênio entre o Ministério de Ciência e Tecnologia, o Instituto de Energia e Ambiente da USP, a Secretaria de Energia do Estado de Sao Paulo e a organização não governamental Biomass Users Network. Mais tarde, quando o convênio entre as instituiçoes expirou, o CENBIO passou a ser um grupo de pesquisa em bioenergia localizado na Universidade de São Paulo, no Instituto de Energia e Ambiente, cuja equipe atualmente compõe o GBIO, após

## GBio participa

UNIVERSITY OF OXFORD

THE CAREERS SERVICE

# GBIO Research Lines

**Bioenergy Planning**

- Biomass assessment – Biomass Atlas
- Biogas & biomethane
- Bioenergy policies – Biogas & biomethane - Project 27 – RCGI/Fapesp/Shell

**Environmental impacts – Life cycle assessment**

- Biodiesel (from soy, animal fat, residual oils)
- Ethanol production - Energy conversion from biomass
- Municipal Solid Waste (MSW) – WtE
- BECCS (Bioenergy and Carbon Capture, Storage and Use)

**Small scale biomass-based energy conversion**

- Energy access in remote villages (Amazonia)
- Waste to Energy technologies for small municipalities

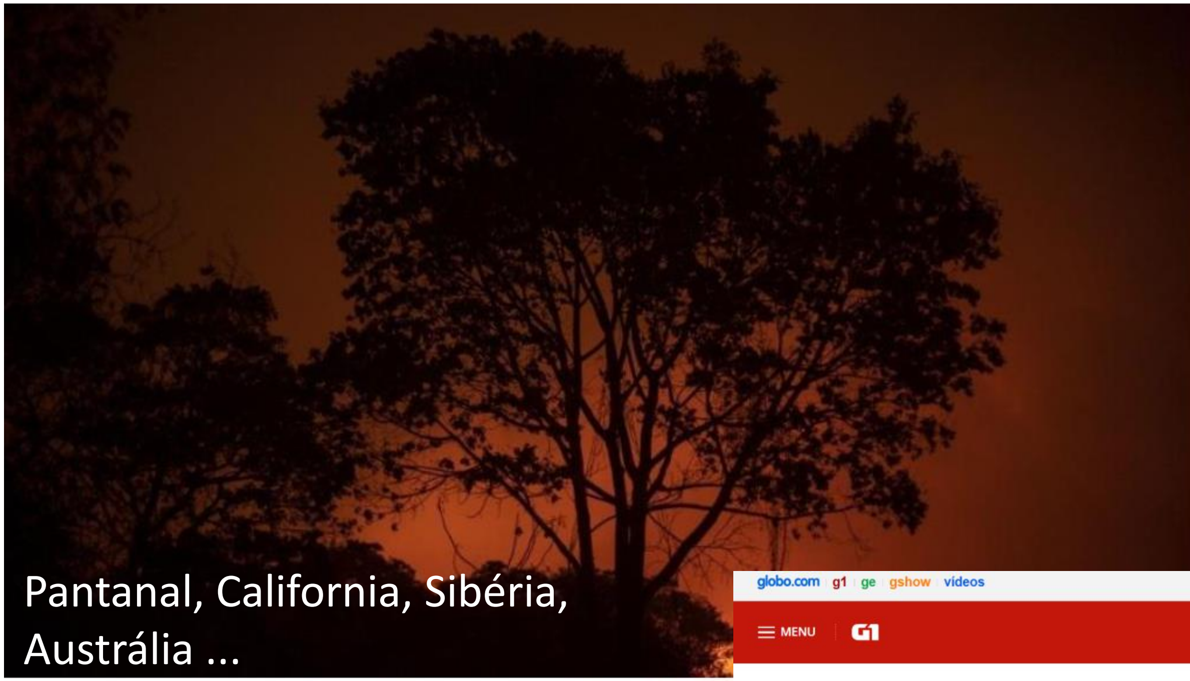
# IRMA HURRICANE - HAVANA


https://g1.globo.com/mundo/noticia/furacao-irma-chega-ao-caribe-fotos.ghtml

IEE USP

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


https://g1.globo.com/mundo/noticia/furacao-irma-chega-ao-caribe-fotos.ghtml https://noticias.uol.com.br/meio-ambiente/ultimas-noticias/redacao/2020/09/22/pantanal-passa-de-16-mil-focos-de-incendio-pior-n-ja-registrado-pelo-inpe.htm




Fogo atinge vegetação próxima à Rodovia Transpantaneira, no Pantanal de Matc

globo.com | g1 | ge | gshow | vídeos

MENU G1 NATUREZA

# Não é só o Pantanal: incêndios florestais pelo mundo são os maiores 'em escala e em emissões de CO2' em 18 anos

Fogo arde na costa oeste dos Estados Unidos, em Nova Gales do Sul, na Austrália, no Ártico Siberiano e no Pantanal brasileiro, mas chamas têm naturezas diferentes.

Por BBC

18/09/2020 12h01 · Atualizado há 5 dias

# BIOENERGY CONTRIBUTING TO ACHIEVE THE SUSTAINABLE DEVELOPMENT GOALS


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

# OBJETIVOS DA PEN-5014

Capacitar o profissional para a análise técnica, econômica, social, ambiental e político-institucional da biomassa como fonte de energia, nos diferentes setores que utilizam este energético, no país e no mundo, considerando a importância cada vez maior desta energia renovável na matriz energética mundial e para os países em desenvolvimento.

# PEN 5014 - Conteúdo

- Biomassa como fonte de energia
- Etanol e Biodiesel
- Cogeração de eletricidade a partir de biomassa
    - Setor sucroalcooleiro
    - Setor de papel e celulose
    - Setor de madeira
- Resíduos urbanos
    - Biogás de aterros
    - Incineração
    - Gaseificação
- Resíduos rurais - Biodigestão
- Resíduos de madeira - pellets
- Tecnologias de segunda geração para biocombustíveis

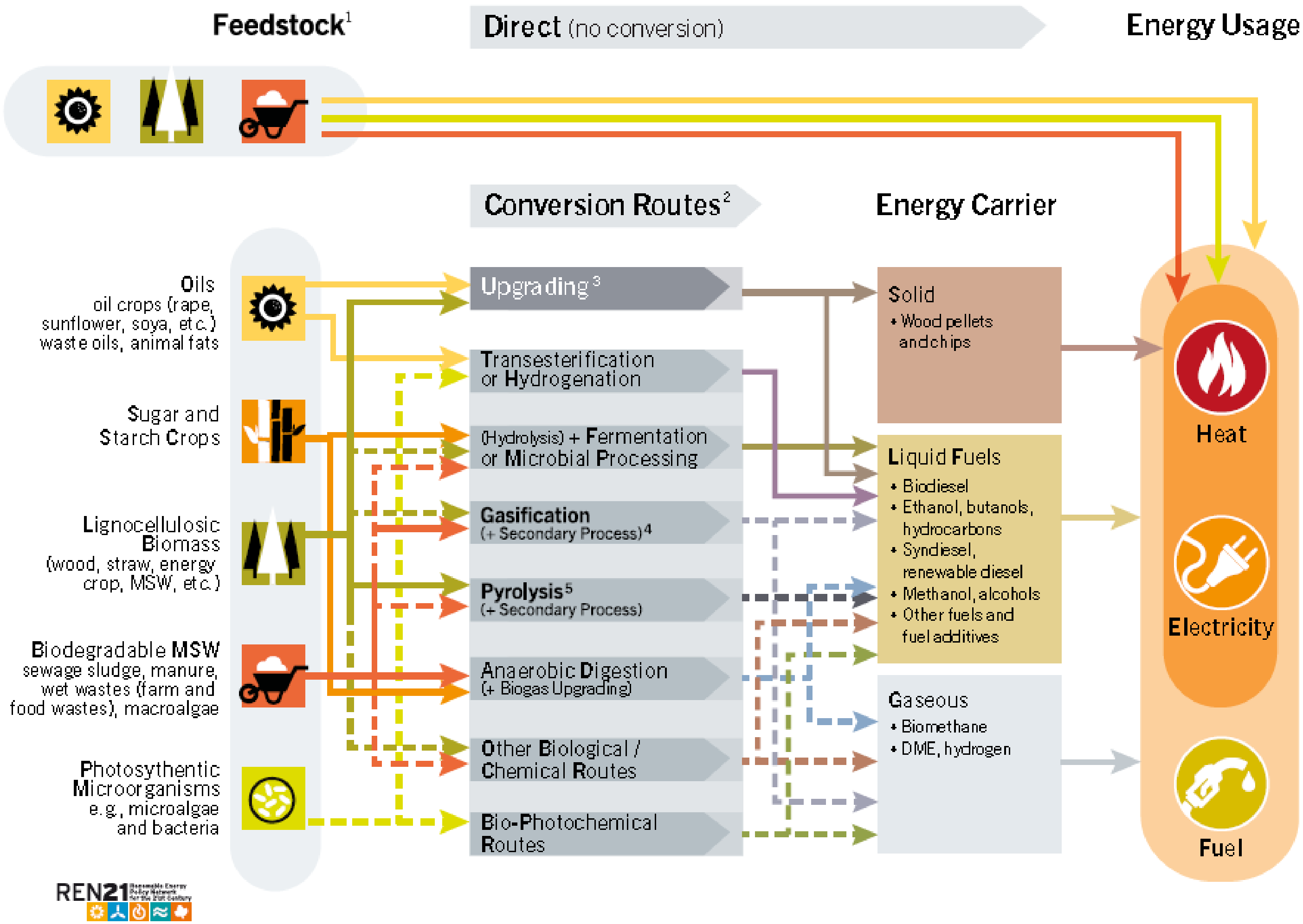
# Cronograma

| PLANEJAMENTO PPGE- 2020 | | AULAS VIRTUAIS | 9-13 hs |
|---|---|---|---|
| **Data** | **Conteúdo** | | **Responsável** |
| 25/set | Apresentação | | SUANI |
| 02/out | Etanol | | SUANI |
| 09/out | Biodiesel | | SUANI |
| 16/out | Madeira | | Escobar/ Monica |
| 23/out | Biogas | | VANESSA |
| 30/out | Ex Biogas/palestra PD | | VANESSA |
| 06/nov | Cogeração | | SUANI |
| 13/nov | Exercicios cogeração | | SUANI |
| 27/nov | RSU | | SUANI |
| 04/dez | Palestras | | Marilin/Djalma/Escobar/Danilo |
| 11/dez | Apresentação de trabalho | | SUANI |
| 18/dez | Apresentação de trabalho | | SUANI |

**CRITERIO DE AVALIAÇÃO**

- **Exercícios em casa – 20%**
- **Apresentação do Trabalho Final – 40%**
- **Trabalho Final – 40%**

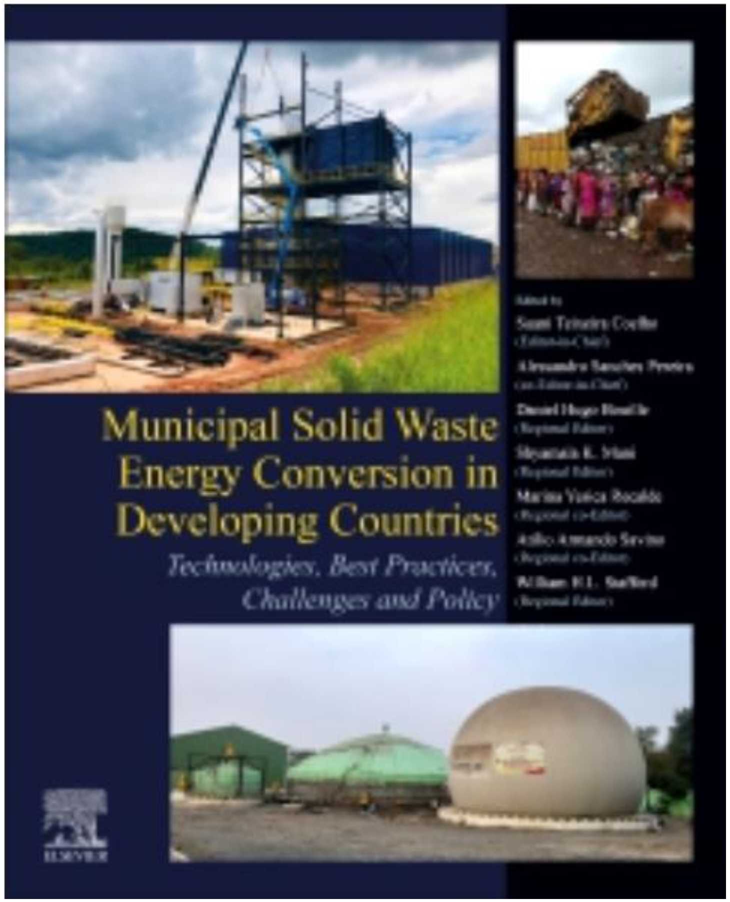
**Figure 6.** Bioenergy Conversion Pathways




Source: See Endn for this se

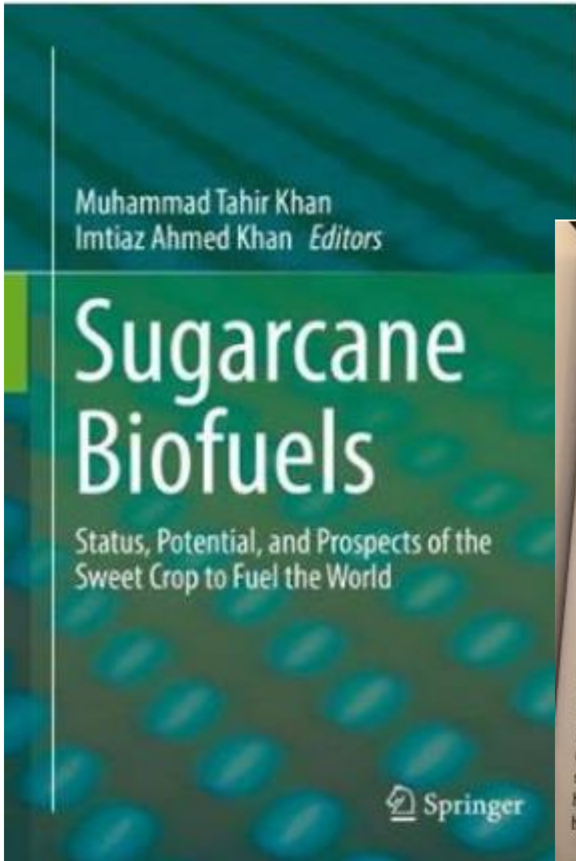
Note: Solid lines represent commercial pathways, and dotted lines represent developing bioenergy routes.

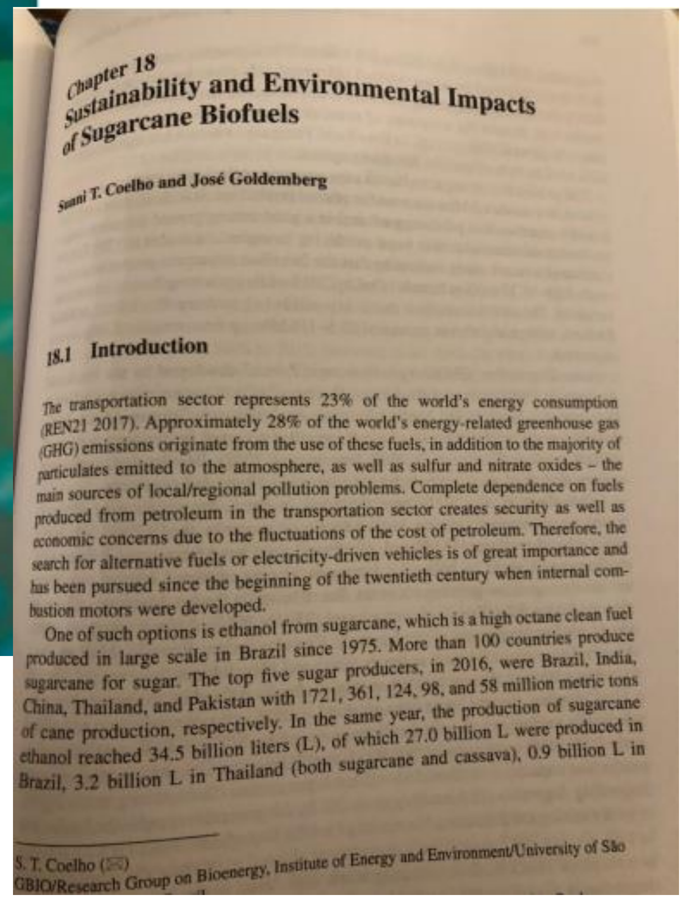
[1] Parts of each feedstock, e.g., crop residues, could also be used in other routes. [2] Each route also gives co-products. [3] Biomass upgrading includes any one of the densification processes (pelletisation, pyrolysis, torrefaction, etc.). [4] Anaerobic digestion processes release methane and $CO_2$, 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.




https://www.elsevier.com/books/municipal-solid-waste-energy-conversion-in-developing-countries/coelho/978-0-12-813419-1


http://gbio.webhostusp.sti.usp.br/?q=pt-br/noticia/e-book-tecnologias-de-produ%C3%A7%C3%A3o-e-uso-de-biog%C3%A1s-e-biometano





Chapter 18
Sustainability and Environmental Impacts of Sugarcane Biofuels

Suani T. Coelho and José Goldemberg

18.1 Introduction

The transportation sector represents 23% of the world's energy consumption (REN21 2017). Approximately 28% of the world's energy-related greenhouse gas (GHG) emissions originate from the use of these fuels, in addition to the majority of particulates emitted to the atmosphere, as well as sulfur and nitrate oxides – the main sources of local/regional pollution problems. Complete dependence on fuels produced from petroleum in the transportation sector creates security as well as economic concerns due to the fluctuations of the cost of petroleum. Therefore, the search for alternative fuels or electricity-driven vehicles is of great importance and has been pursued since the beginning of the twentieth century when internal combustion motors were developed.

One of such options is ethanol from sugarcane, which is a high octane clean fuel produced in large scale in Brazil since 1975. More than 100 countries produce sugarcane for sugar. The top five sugar producers, in 2016, were Brazil, India, China, Thailand, and Pakistan with 1721, 361, 124, 98, and 58 million metric tons of cane production, respectively. In the same year, the production of sugarcane ethanol reached 34.5 billion liters (L), of which 27.0 billion L were produced in Brazil, 3.2 billion L in Thailand (both sugarcane and cassava), 0.9 billion L in

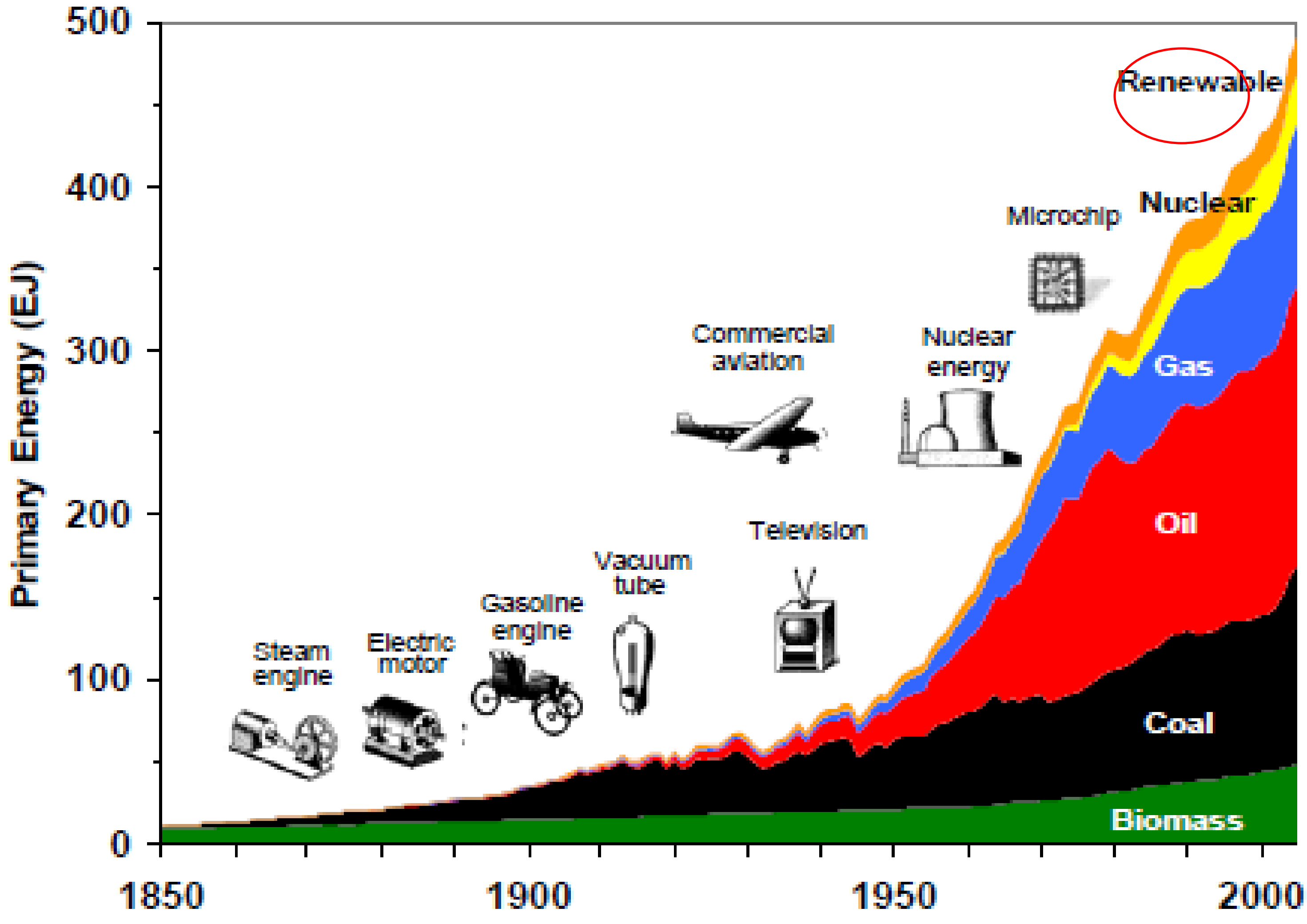
S. T. Coelho (✉)
GBIO/Research Group on Bioenergy, Institute of Energy and Environment/University of São

# Publicações em periódicos e livros – 2019/20

- Silva-Martínez, R., Sanches-Pereira, A., Ortiz, W., Galindo, M., **Coelho, S.** (2020). The state-of-the-art of organic waste to energy in Latin America and the Caribbean: Challenges and opportunities. Renewable Energy 156, 509-525. DOI: 10.1016/j.renene.2020.04.056.
- Pischke, E.C., Solomon, B., Wellstead, A., Acevedo, A., Eastmond, A., De Oliveira, F., **Coelho, S.**, Lucon, O. (2019). From Kyoto to Paris: Measuring renewable energy policy regimes in Argentina, Brazil, Canada, Mexico and the United States. Energy Research & Social Science 50, 82-91. DOI: 10.1016/j.erss.2018.11.010.
- De Oliveira, F., Lopes, T., Parente, V., Bermann, C., **Coelho, S.** (2019). The Brazilian social fuel stamp program: Few strikes, many bloopers and stumbles. Renewable and Sustainable Energy Reviews 102, 121-128. DOI: 10.1016/j.rser.2018.12.011.
- Huang, J., Khan, M., Perecin, D., **Coelho, S.**, Zhang, M. (2020). Sugarcane for bioethanol production: Potential of bagasse in Chinese perspective. Renewable and Sustainable Energy Reviews 133, 110296. DOI: 10.1016/j.rser.2020.110296.
- **Coelho, S.** et al. (2020). Municipal Solid Waste Energy Conversion in Developing Countries: Technologies, Best Practices, Challenges and Policy. Elsevier. DOI: 10.1016/C2015-0-04596-8.
- 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.
- **Coelho, S.**, Perecin, D., Rei, F., Escobar, J., Freiria, R., Kimura, W. Bioenergy Policies Worldwide. In Trevor M. Letcher (main ed.) Comprehensive Renewable Energy 2nd edition, Volume 5: Biomass and biofuel production. Elsevier [aguardando publicação].
- **Coelho, S.**, Diaz-Chavez, R., Cortez, C., Perecin, D., Possetti, G., Rietow, J., Silva, C. Circular Economy in Brazil. In Ghosh, S., Ghosh, S. Circular Economy: Recent trends in global perspective. Springer Nature [aguardando publicação].
- **Coelho, S.**, Infiesta, L., Garcilasso, V. Waste-to-Energy Technologies: Gasification and Pyrolysis. In Advances in Clean Energy: Production and Application. Elsevier [aguardando publicação].

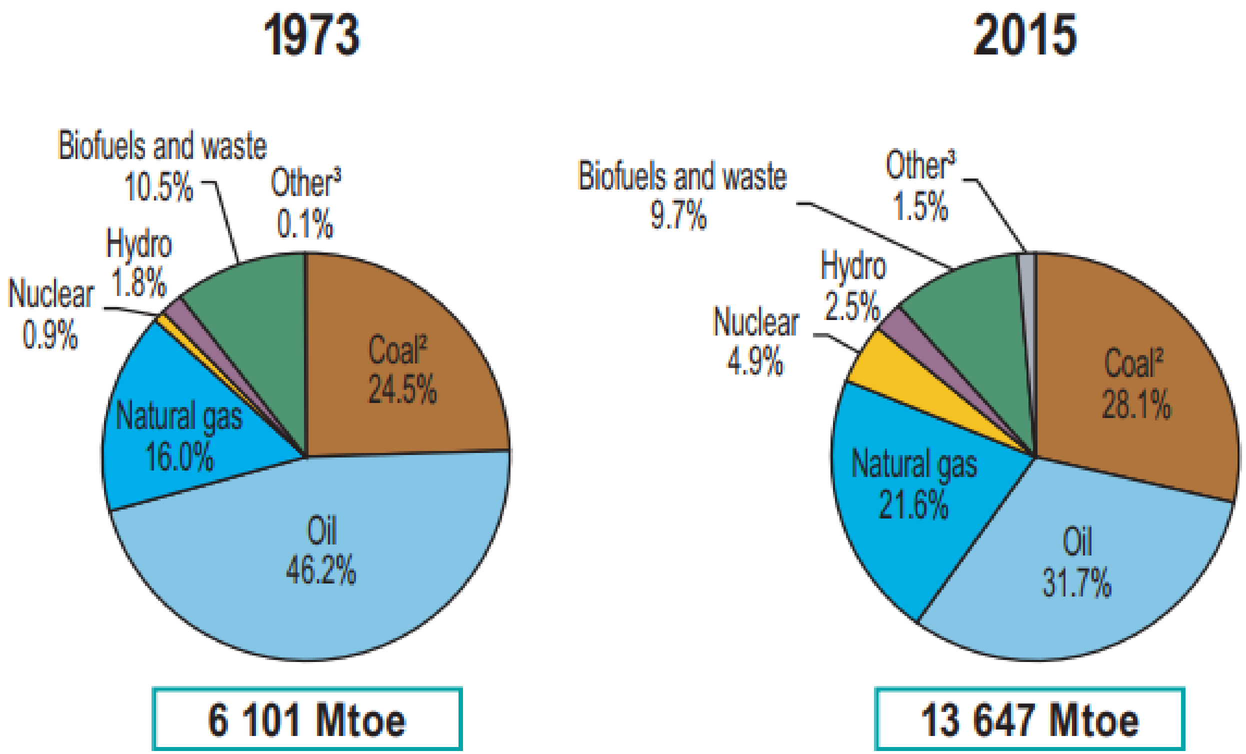
- De Oliveira, F, Coelho, S. Biodiesel in Brazil Should Take Off with the Newly Introduced Domestic Biofuels Policy: RenovaBio. In: Biofuels - Challenges and opportunities. DOI: 10.5772/intechopen.79670. https://www.intechopen.com/online-first/biodiesel-in-brazil-should-take-off-with-the-newly-introduced-domestic-biofuels-policy-renovabio.

## Energia x evolução tecnológica
## (GEA, IIASA,2013)



# World energy supply

1973 and 2015 fuel shares of TPES




*3. Includes geothermal, solar, wind, tide/wave/ocean, heat and other.*

Source: IEA Key World Energy Statistics 2017.
https://www.iea.org/publications/freepublications/publication/KeyWorld2017.pdf

TPES: Total Primary Energy Supply

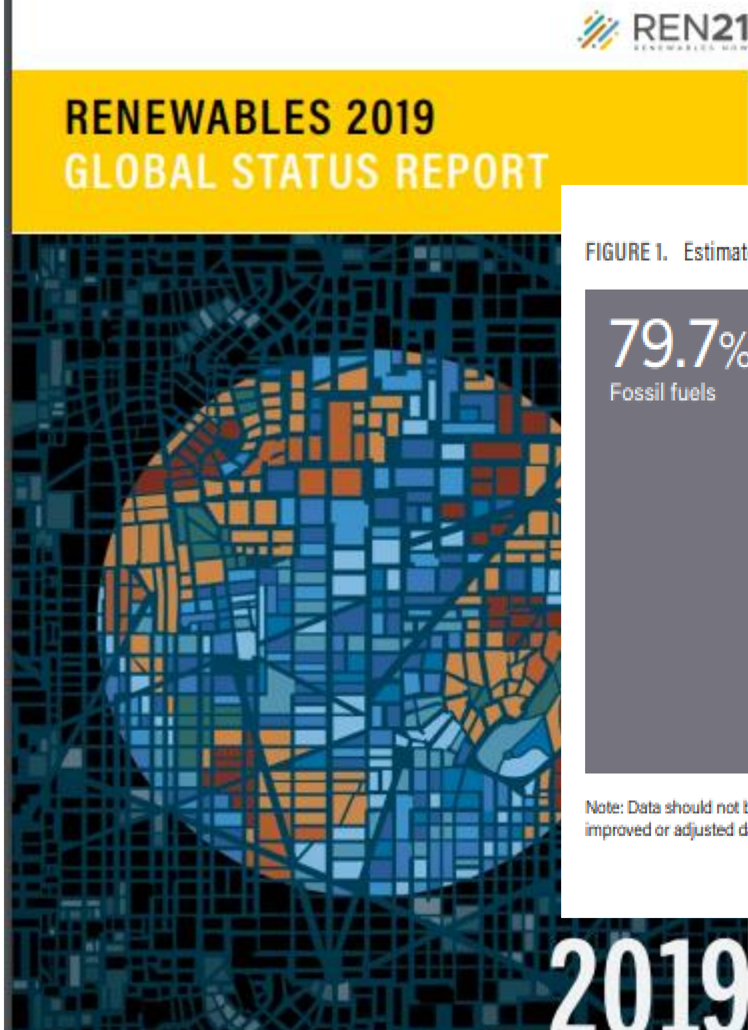
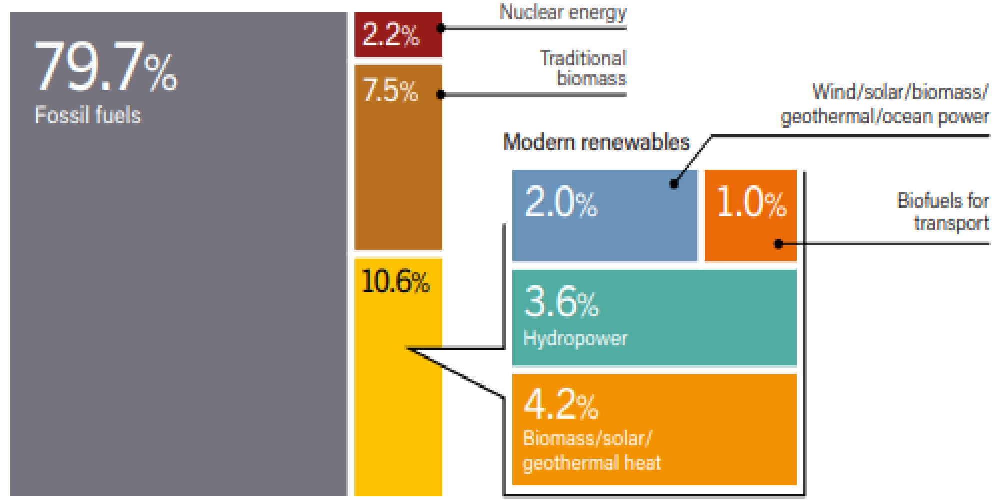



FIGURE 1. Estimated Renewable Share of Total Final Energy Consumption, 2017




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

# TOP FIVE COUNTRIES

**Annual Investment / Net Capacity Additions / Production in 2018**

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Investment in renewable power and fuels (not including hydropower over 50 MW) | **China** | United States | Japan | India | Australia |
| Investment in renewable power and fuels per unit GDP[1] | **Palau** | Djibouti | Morocco | Iceland/Serbia | |
| Geothermal power capacity | **Turkey** | Indonesia | United States | Iceland | New Zealand |
| Hydropower capacity | **China** | Brazil | Pakistan | Turkey | Angola |
| Solar PV capacity | **China** | India[2]/United States | | Japan | Australia |
| Concentrating solar thermal power (CSP) capacity | **China/Morocco** | | South Africa | Saudi Arabia | – |
| Wind power capacity | **China** | United States | Germany | India | Brazil |
| Solar water heating capacity | **China** | Turkey | India | Brazil | United States |
| Biodiesel production | **United States** | Brazil | Indonesia | Germany | Argentina |
| Ethanol production | **United States** | Brazil | China | Canada | Thailand |

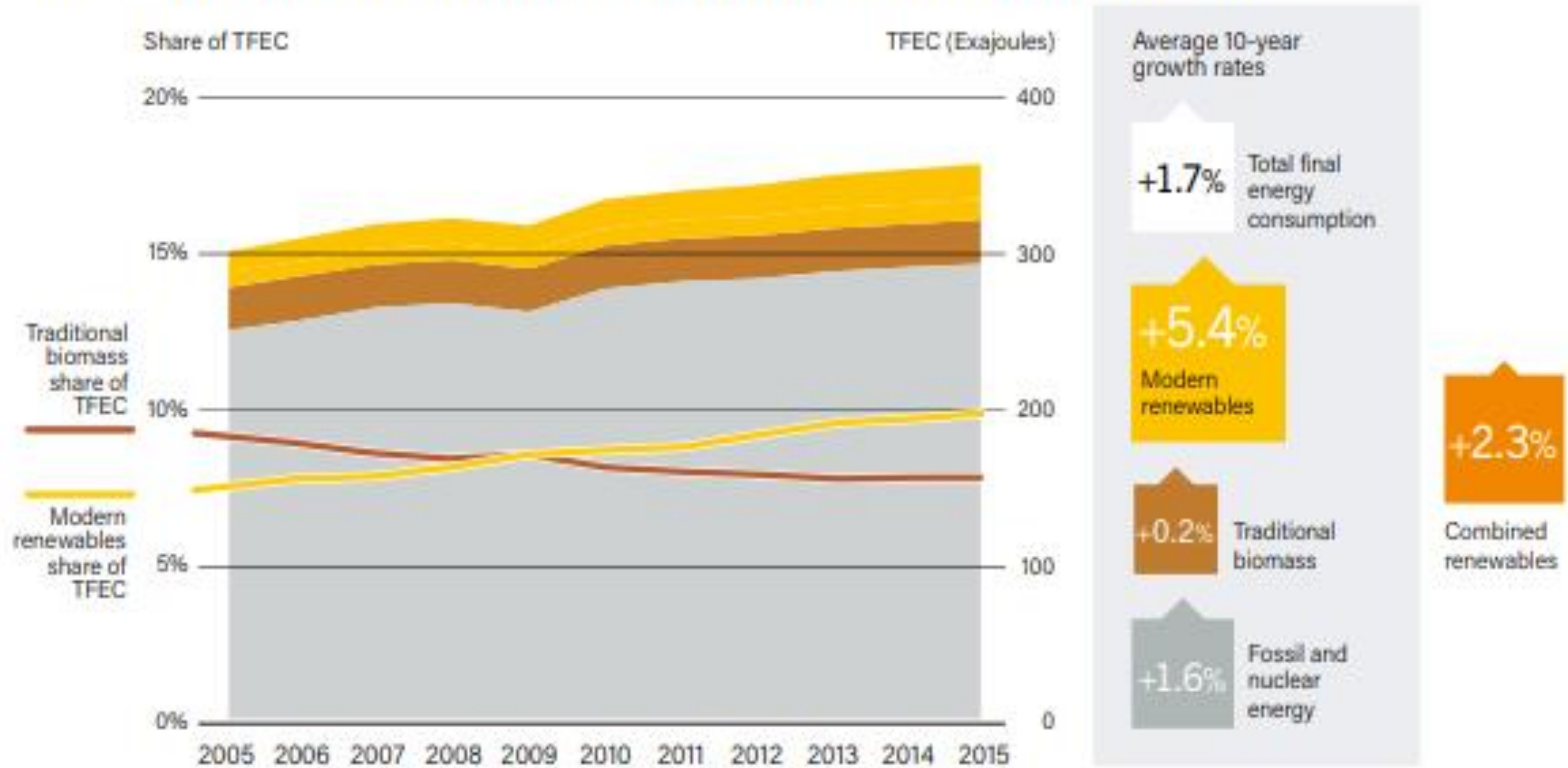
**Total Capacity or Generation as of End-2018**

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **POWER** | | | | | |
| Renewable power capacity (including hydropower) | **China** | United States | Brazil | India | Germany |
| Renewable power capacity (not including hydropower) | **China** | United States | Germany | India | Japan |
| Renewable power capacity per capita (not including hydropower)[3] | **Iceland** | Denmark | Germany/Sweden | | Finland |
| Bio-power generation | **China** | United States | Brazil | Germany | India |
| Bio-power capacity | **China** | United States | Brazil | India | Germany |
| Geothermal power capacity | **United States** | Indonesia | Philippines | Turkey | New Zealand |
| Hydropower capacity[4] | **China** | Brazil | Canada | United States | Russian Federation |
| Hydropower generation[4] | **China** | Canada | Brazil | United States | Russian Federation |
| Solar PV capacity | **China** | United States | Japan | Germany | India |
| Solar PV capacity per capita | **Germany** | Australia | Japan | Belgium | Italy |
| Concentrating solar thermal power (CSP) capacity | **Spain** | United States | South Africa | Morocco | India |
| Wind power capacity | **China** | United States | Germany | India | Spain |
| Wind power capacity per capita | **Denmark** | Ireland | Germany | Sweden | Portugal |
| **HEAT** | | | | | |
| Solar water heating collector capacity[5] | **China** | United States | Turkey | Germany | Brazil |
| Solar water heating collector capacity per capita | **Barbados** | Austria | Cyprus | Israel | Greece |
| Geothermal heat output[6] | **China** | Turkey | Iceland | Japan | Hungary |

## RENEWABLE ENERGY INDICATORS 2018

| | | 2017 | 2018 |
|---|---|---|---|
| **INVESTMENT** | | | |
| New investment (annual) in renewable power and fuels[1] | billion USD | 326 | **289** |
| **POWER** | | | |
| Renewable power capacity (including hydropower) | GW | 2,197 | **2,378** |
| Renewable power capacity (not including hydropower) | GW | 1,081 | **1,246** |
| Hydropower capacity[2] | GW | 1,112 | **1,132** |
| Wind power capacity | GW | 540 | **591** |
| Solar PV capacity[3] | GW | 405 | **505** |
| Bio-power capacity | GW | 121 | **130** |
| Geothermal power capacity | GW | 12.8 | **13.3** |
| Concentrating solar thermal power (CSP) capacity | GW | 4.9 | **5.5** |
| Ocean power capacity | GW | 0.5 | **0.5** |
| Bioelectricity generation (annual) | TWh | 532 | **581** |
| **HEAT** | | | |
| Solar hot water capacity[4] | $GW_{th}$ | 472 | **480** |
| **TRANSPORT** | | | |
| Ethanol production (annual) | billion litres | 104 | **112** |
| FAME biodiesel production (annual) | billion litres | 33 | **34** |
| HVO biodiesel production (annual) | billion litres | 6.2 | **7.0** |
| **POLICIES[5]** | | | |
| Countries with national/state/provincial renewable energy targets[6] | # | 179 | **169** |
| Countries with 100% renewable energy in primary or final energy targets | # | 1 | **1** |
| Countries with 100% renewable heating and cooling targets | # | 1 | **1** |
| Countries with 100% renewable transport targets | # | 1 | **1** |
| Countries with 100% renewable electricity targets | # | 57 | **65** |
| States/provinces/countries with heat obligations/mandates | # | 19 | **18** |
| States/provinces/countries with biofuel mandates[7] | # | 70 | **70** |
| States/provinces/countries with feed-in policies | # | 112 | **111** |
| States/provinces/countries with RPS/quota policies | # | 33 | **33** |
| Countries with tendering (held in 2018) | # | 29 | **48** |
| Countries with tendering (cumulative)[8] | # | 84 | **98** |

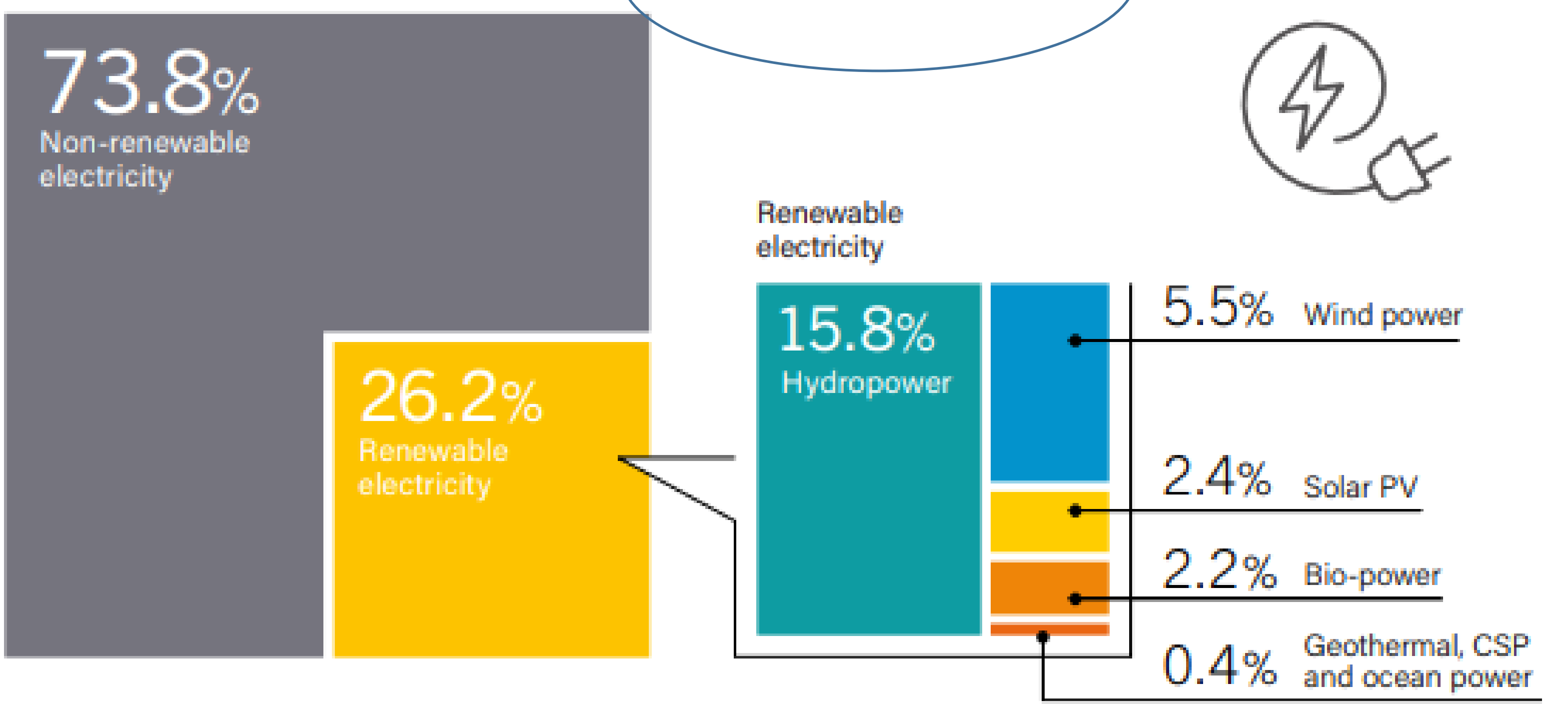
FIGURE 2. Growth in Global Renewable Energy Compared to Total Final Energy Consumption, 2005-2015




Note: Combined renewables = both modern renewables and traditional biomass.

Source: See endnote 23 for this chapter.

FIGURE 8. Estimated Renewable Energy Share of Global Electricity Production, End-2018

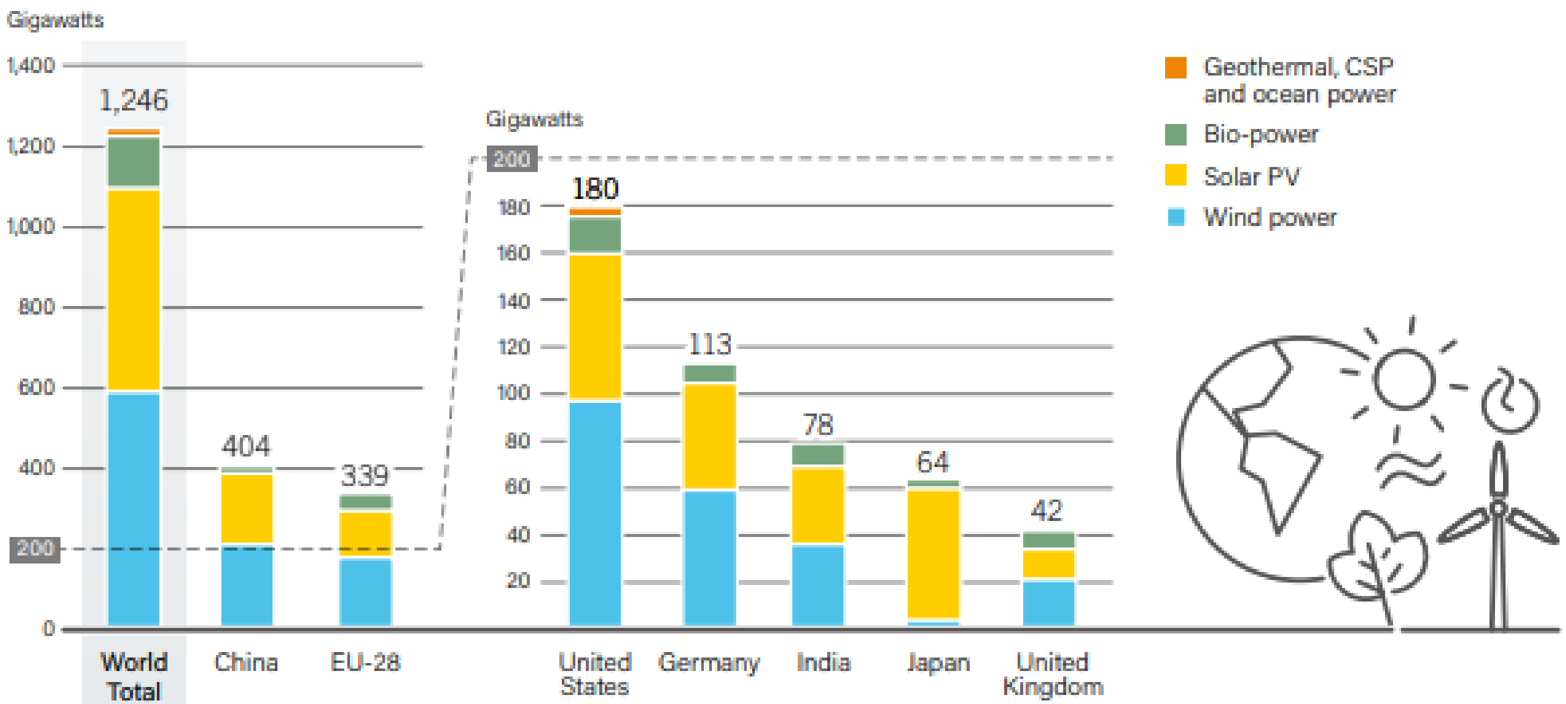



Note: Data should not be compared with previous versions of this figure due to revisions in data and methodology.

Source: See endnote 192 for this chapter.

Source: REN 21 Global Status Report (2019)

FIGURE 9. Renewable Power Capacities in World, EU-28 and Top 6 Countries, 2018

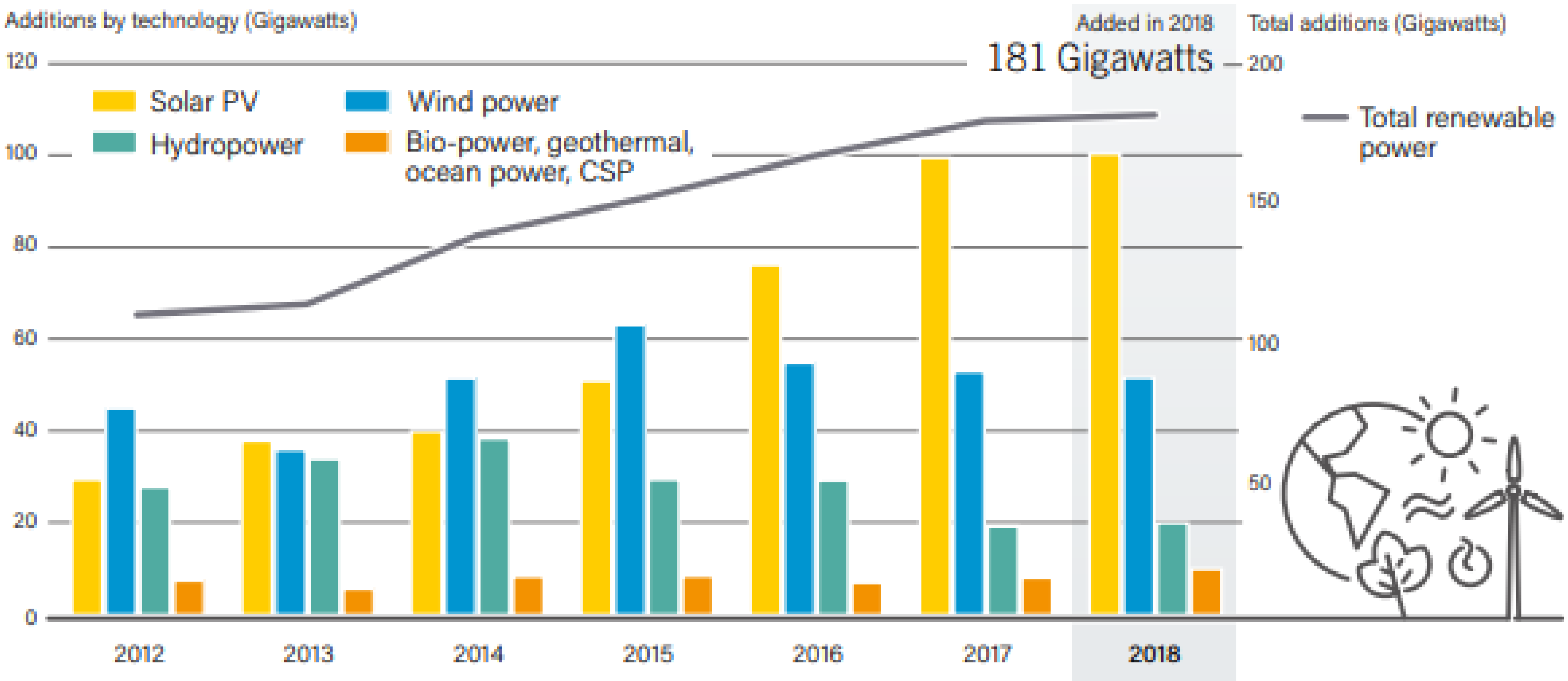



Note: Not including hydropower.

Source: See endnote 195 for this chapter.

Source: REN 21 Global Status Report (2019)

FIGURE 6. Annual Additions of Renewable Power Capacity, by Technology and Total, 2012-2018




Note: Solar PV capacity data are provided in direct current (DC).

Source: See endnote 183 for this chapter.

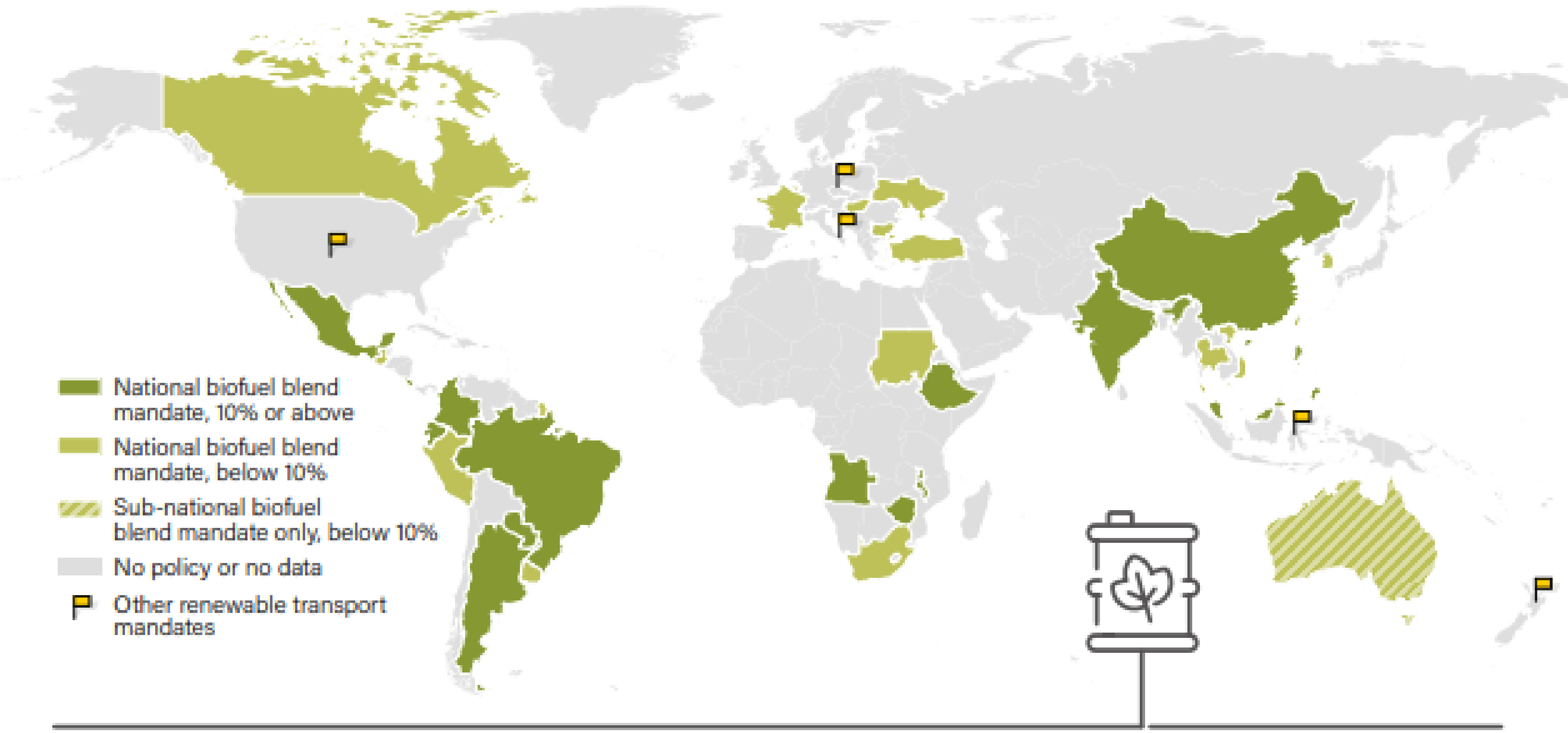
TABLE 1. Estimated Direct and Indirect Jobs in Renewable Energy, by Country/Region and Technology, 2017-2018

| | World | China | Brazil | United States | India | European Union[l] |
|---|---|---|---|---|---|---|
| | Thousand jobs | | | | | |
| Solar PV | **3,605**[e] | 2,194 | 15.6 | 225 | 115[k] | 96 |
| Liquid biofuels | **2,063** | 51 | 832[g] | 311[h] | 35 | 208 |
| Hydropower[a] | **2,054** | 308 | 203 | 66.5 | 347 | 74 |
| Wind power | **1,160** | 510 | 34 | 114 | 58 | 314 |
| Solar thermal heating/cooling | **801** | 670 | 41 | 12 | 20.7 | 24[m] |
| Solid biomass[b, c] | **787** | 186 | | 79[i] | 58 | 387 |
| Biogas | **334** | 145 | | 7 | 85 | 67 |
| Geothermal energy[b,d] | **94** | 2.5 | | 35[j] | | 23 |
| Concentrating solar thermal power (CSP) | **34** | 11 | | 5 | | 5 |
| **Total** | **10,983**[f] | **4,078** | **1,125** | **855** | **719** | **1,235**[n] |

IEE USP

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

FIGURE 15. National and Sub-National Renewable Transport Mandates, 2018




Note: Shading shows countries and states/provinces with mandates for either biodiesel, ethanol or both. Other renewable transport mandates include mandates for advanced biofuels and for sectors other than road transport, among others. See Reference Table R10.

Source: REN21 Policy Database.

BIOENERGIA – FONTE RENOVÁVEL

NDC BRASIL (NATIONAL DETERMINED CONTRIBUTION) – ACORDO DE PARIS


http://www.mma.gov.br/clima/convencao-das-nacoes-unidas/acordo-de-paris

O QUE É BIOMASSA?

O QUE É BIOENERGIA?

## *What is Bioenergy? (IEA Bioenergy)*

- **Traditional biomass:** Burning harvested organic matter – biomass - provided most of mankind's energy needs for millenia. Using such fuels is still the primary energy source for many people in developing and emerging economies, but such "traditional use" of biomass is often unsustainable, with inefficient combustion leading to harmful emissions with serious health implications.
- **Modern technologies** can convert this organic matter to solid, liquid and gaseous forms that can more efficiently replace fossil fuels.
- A wide range of **biomass feedstocks** can be used as sources of **bioenergy**:
  - wet organic wastes, such as sewage sludge, animal wastes and organic liquid effluents, and the organic fraction of municipal solid waste (MSW);
  - residues from agro-industries, agriculture and forestry;
  - crops grown for energy, including food crops such as corn, wheat, sugar and
  - vegetable oils produced from palm, rape-seed and other raw materials; and non-food crops such as perennial lignocellulosic plants (e.g. grasses such as miscanthus and trees such as short-rotation willow and eucalyptus) and oil-bearing plants (such as jatropha and camelina).

Source: IEA, 2017 – Bioenergy Technology Roadmap

# 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

# Problemas com o atual sistema energético mundial

i. Equidade

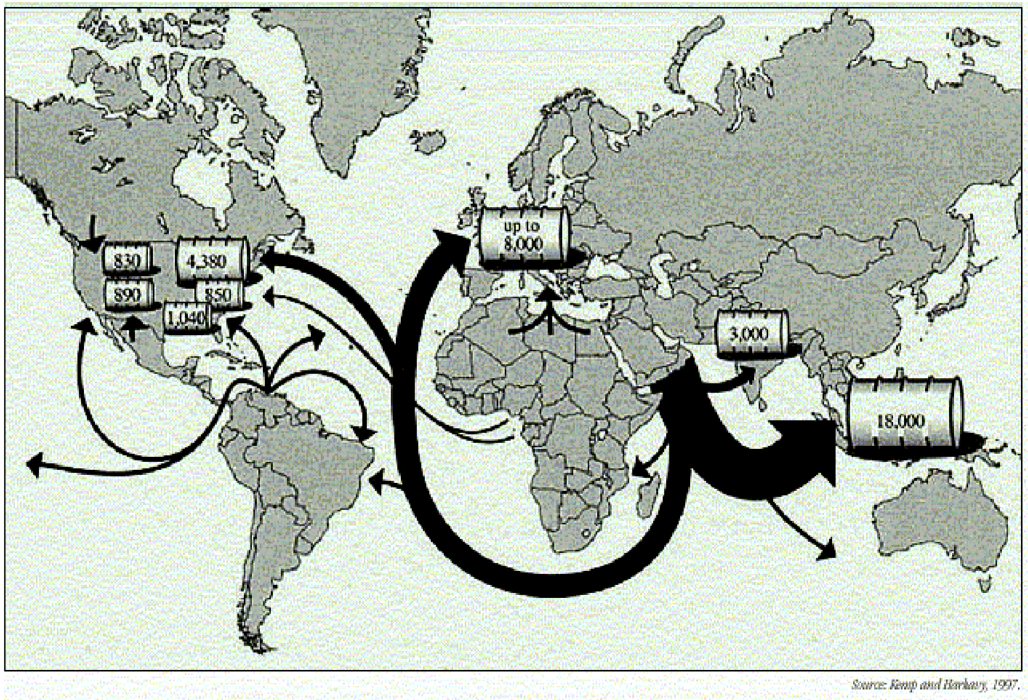
ii. Exaustão das reservas (fósseis)

iii. Segurança de abastecimento

iv. Impactos ambientais (impactos globais/emissões de carbono/efeito estufa e impactos locais)

## Vantagens das Energias Renováveis
## Segurança de abastecimento

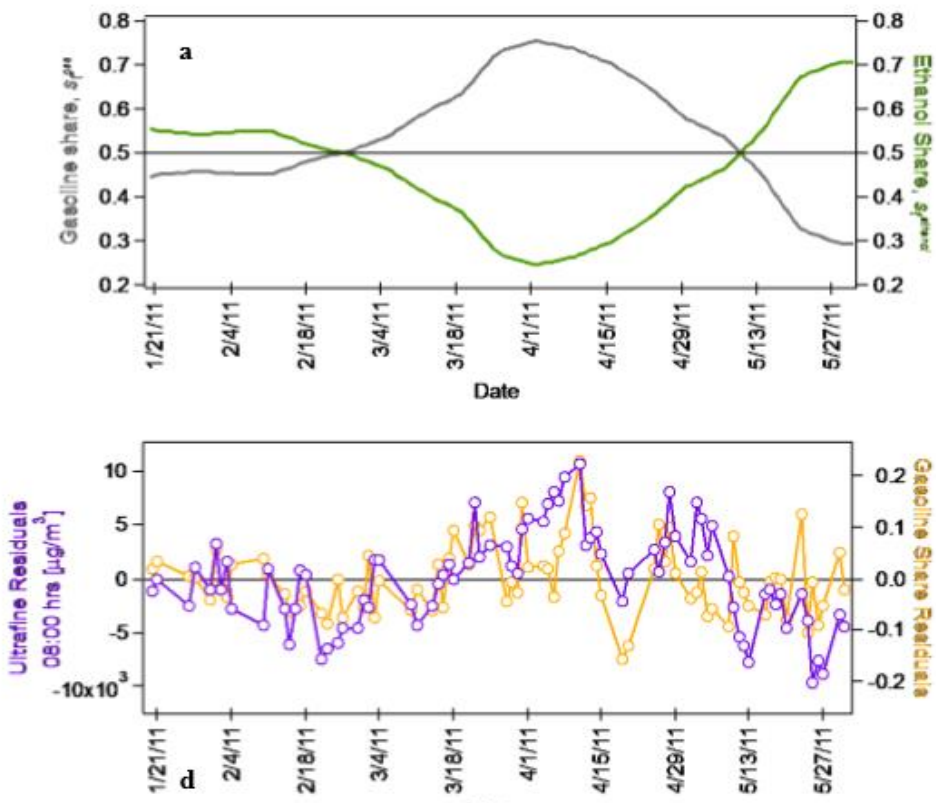
- Aumento da diversidade de mercados fornecedores de energia, bem como da **segurança de suprimento**, pois não depende da combustíveis fósseis importados.



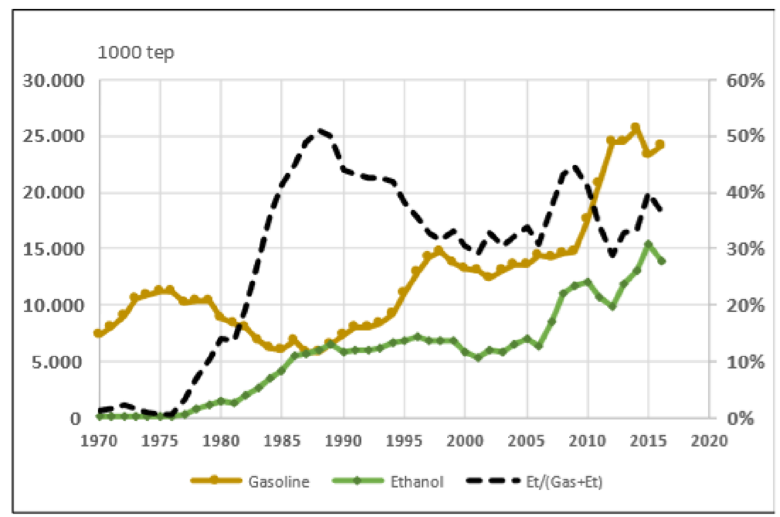

**Fluxos de petróleo no mundo. Fonte: UNDP, UNDESA, WEC, 2002**

# Vantagens das Energias Renováveis – Impactos ambientais (locais)

*Reduced ultrafine particle levels in São Paulo's atmosphere during shifts from gasoline to ethanol use (Redução na concentração de particulados ultrafinos na atmosfera de SP durante mudança de gasolina para etanol)*




**Participação do etanol (anidro e hidratado) no consumo de veículos leves (motor Otto) no Brasil**



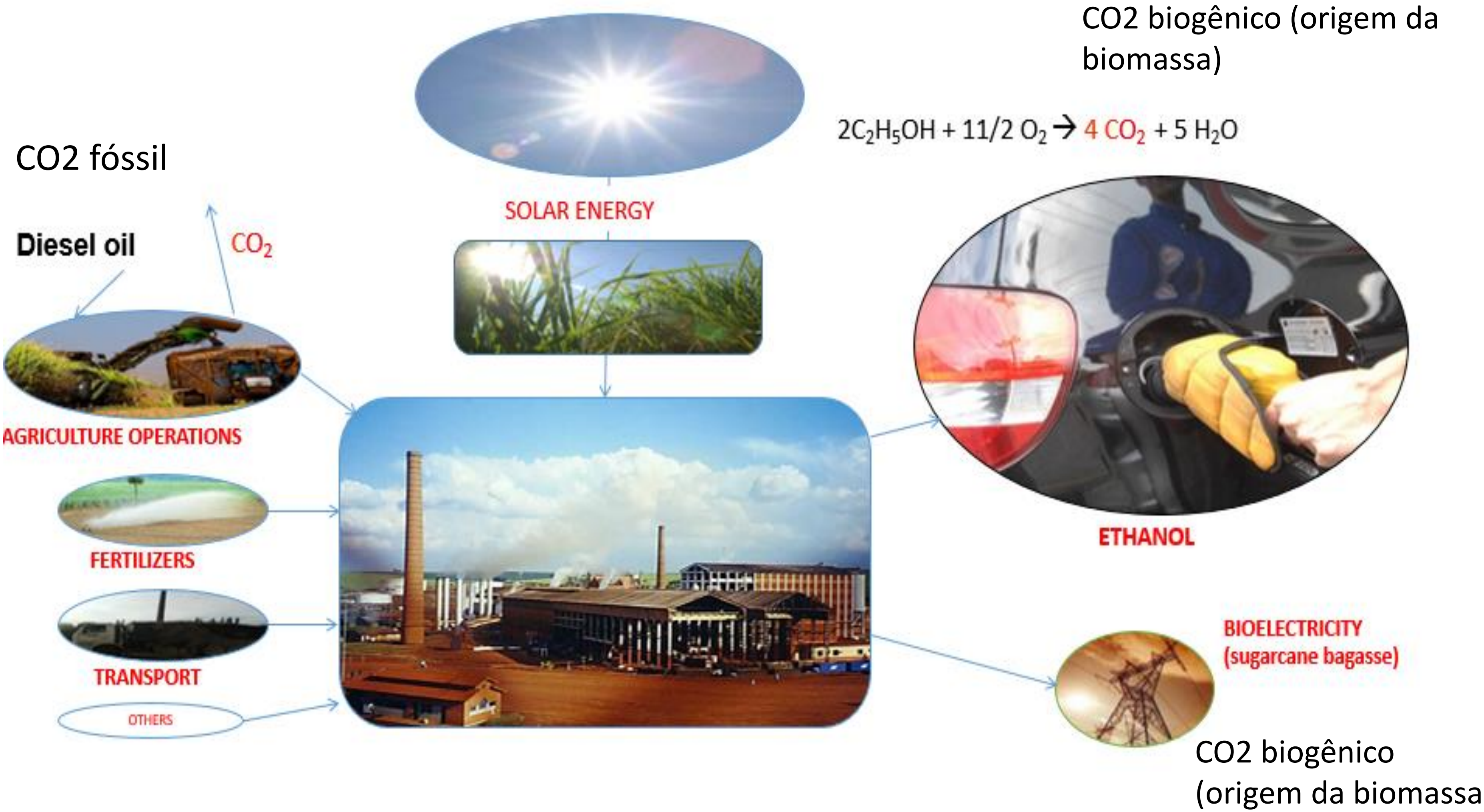

Fonte: BEN, 2017

NATURE COMMUNICATIONS | 8: 77 | DOI: 10.1038/s41467-017-00041-5 | www.nature.com/naturecommunications

Alberto Salvo, Joel Brito, Paulo Artaxo & Franz M. Geiger

# GHG EMISSIONS - WHY BIOENERGY TO REDUCE CARBON EMISSIONS?

## Ethanol Energy Balance from Sugarcane

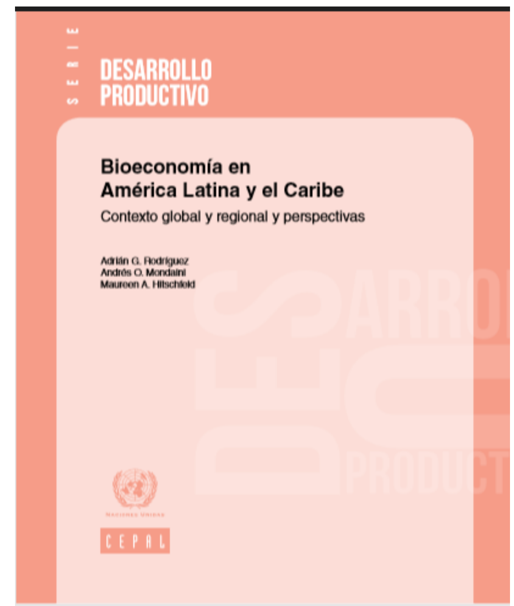


# Bioeconomy (residues)

- Interesting option to diversify local production
- Important issue for Developing Countries (DC)
- Sustainability x development
- Value addded to rural areas
- Bioeconomy – sustainable development

# Trends on Bioeconomy in Latin America

- Economy based on the consumption and production of goods and services:
  - Sustainable transformation of biological resources,
  - Including biogenic waste generated in the processes of transformation, production and consumption.
- Taking advantage of knowledge of biological processes and principles and
- Technologies applicable to the knowledge and transformation.




https://www.cepal.org/en/news/what-bioeconomy-and-how-developed-it-latin-america-and-caribbean

# BIOECONOMY IN ARGENTINA


https://www.agroindustria.gob.ar/sitio/areas/bioeconomia/_archivos//000000_Bioeconomia%20Argentina.pdf

(i) efficient **diversification** of the **energy matrix**,
(ii) design of territorial development strategies for the **generation of income and employment**, based on competitiveness and **sustainability**, and
(iii) promoting **investments** in production sectors (oriented according to the NDC and to the priorities for natural resources conservation and environmental protection established by the country).

**Significant perspectives in Argentina**:

- Availability of biomass and great diversity of types of biomass,
- Well developed scientific and technological system,
- Advances in important applications (biofuels, direct seeding and its linkages and industry of the food)
- New areas: bioplastics, bio-inputs, etc.
- Bioeconomy: still a novel idea and needs to be promoted in order to reach its potential.

# BIOECONOMY IN COLOMBIA

ESTUDIO SOBRE LA BIOECONOMÍA COMO FUENTE DE NUEVAS INDUSTRIAS BASADAS EN EL CAPITAL NATURAL DE COLOMBIA N.° 1240667, FASE I.

PRIORIZACIÓN DE LOS SECTORES ESTRATÉGICOS DE BIOECONOMÍA PARA COLOMBIA

CONSULTORES
Claudia Marcela Betancur G.: experta sectorial y directora del proyecto. BIOINTROPIC
Diego Moñux Chercoles: experto sectorial y política CTI. SILO
Gustavo Canavire B.: experto economista. Universidad EAFIT
Diego Fernando Villanueva: experto técnico. Universidad EAFIT
José García G: análisis de indicadores económicos. Universidad EAFIT
Libia María Renza: análisis de política relacionada. SILO
Katia Méndez N.: análisis de capacidades. BIOINTROPIC
Ana Cristina Zúñiga: análisis de bioeconomía. Corporación Universitaria Lasallista
Elkin Olaguer Pérez. S: análisis de bioeconomía. Universidad de Medellín

Enero 24 de 2018

Entidades de apoyo

Entidades patrocinadoras

- ➢ Agricultural and livestock
- ➢ Processed foods and beverages
- ➢ Health
- ➢ Chemical
- ➢ Pharmaceutical
- ➢ Cosmetic and toilet

- ➢ **<u>Bioenergy</u>**
  - ➢ Renewable energies • Non-fossil fuels.
  - ➢ Bioethanol/Biofuels/Biogas/ Biorefinery

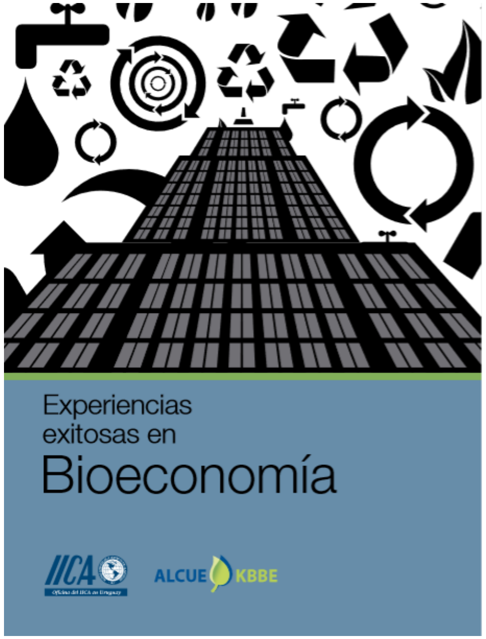
https://www.dnp.gov.co/Crecimiento-Verde/Documents/ejes-tematicos/Bioeconomia/informe%201/1-INFORME%20BIOECONOMIA%20FASE%201%20FINAL%2024012018.pdf

# *BIOECONOMY IN PARAGUAY*

- Main challenge: to **move from a primary export economy, which represents 13% of our economy to a 20% coming from bioeconomy**
- Four fundamental points: conservation, food sovereignty, sustainability and bio industry development.
- Use of environmental goods in the country's productive matrix
- To boost its bioeconomy through:
  - a **good conservation policy**,
  - investing in research and conservation areas
  - to generate an economy at the scale of business emerging markets
  - to work on opening markets for products.

Source: Justo Vargas, 2018. Personal communication. Email: justo.vargas@map.gov.py

# BIOECONOMY IN URUGUAY & MEXICO




http://www.iica.int/sites/default/files/publications/files/2015/b3245e.pdf


http://www.sagarpa.gob.mx/agricultura/Documents/Estrategiabioenergeticos.pdf

# Brazil

Ethanol production 29 billion liters per year

Sales price in pump stations USD 1.00/L

Total ethanol sales

29 billion USD per year

Brazil GDP 1,800 billion USD in 2017

IEE USP

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

# Bioeconomia no Brasil: iniciativas

- **CGEE (Centro de Gestão e Estudos Estratégicos)***
  - Panorama da Bioeconomia no Brasil e identificação das áreas estratégicas (2017)
  - Projeto: Oportunidades e Desafios da Bioeconomia (ODBio)
    - Perspectivas da bioeconomia brasileira com base em inovações tecnológicas e de mercado (2020)
    - Nota Técnica – Mapeamento de capacidades brasileiras em CTI em bioeconomia (2020)
    - Arquitetura operacional de um *knowledge hub* em bioeconomia (2020)
    - Proposta de observatório em bioeconomia (2020)
- **Outras:**
  - **CNI/Harvard** – Bioeconomia: uma agenda para o Brasil (2013)
  - **CNI** – Bioeconomia e a indústria brasileira (2020)
  - **BNDES** – A bioeconomia brasileira em números (2018)
  - **Embrapa** – Desafios para a inserção da bioeconomia brasileira no contexto mundial (2018)
  - **Instituto Escolhas** – Uma nova economia para o Amazonas: Zona Franca de Manaus e Bioeconomia (2019)
  - **Publicações** – Nobre et al. (2016): Land-use and climate change risks in the Amazon and the need of a novel sustainable development paradigm; Machado et al. (2019); etc.
  - **Frente Parlamentar** Mista da Bioeconomia

**- Tema #1: Biomassa e tecnologias associadas**
Produção sustentável de biomassa, incluindo resíduos

**- Tema #2: Processamento de biomassa e biorrefinarias**
Desenvolvimento de insumos, equipamentos e métodos para o pré-tratamento e processamento das biomassas

**- Tema #3: Bioprodutos**
Produtos, processos e serviços de alto valor agregado com a utilização de biomassa – fortalecendo a "química verde" e aspectos de circularidade econômica

Fonte: CGEE (2017)

*Organização supervisionada pelo MCTI (Ministério da Ciência, Tecnologia e Inovações)

# Aproveitamento de resíduos

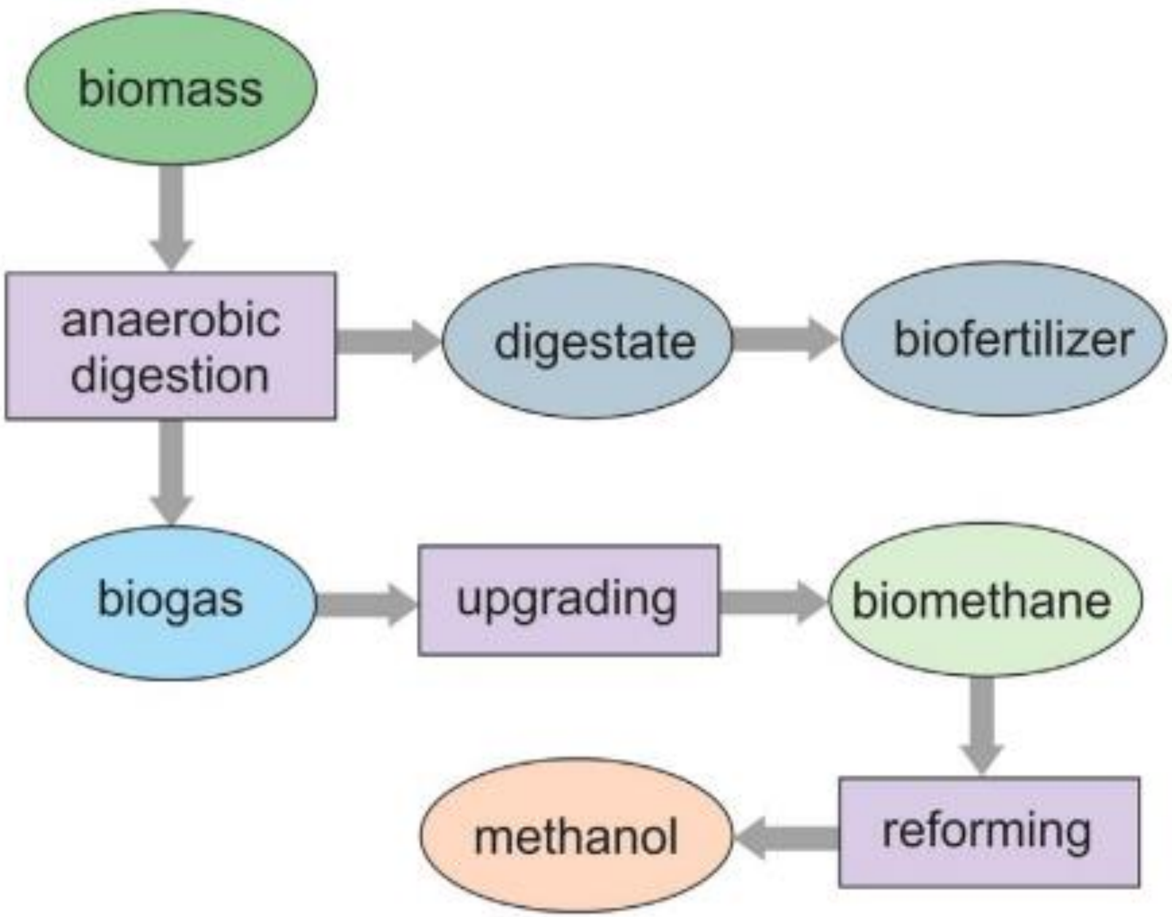



Fig. 9. Production of digestate by anaerobic digestion of residual biomass into biogas. Source: Elaboration of the third author.

https://dc
Received :
Available
1364-032

# Aproveitamento de resíduos



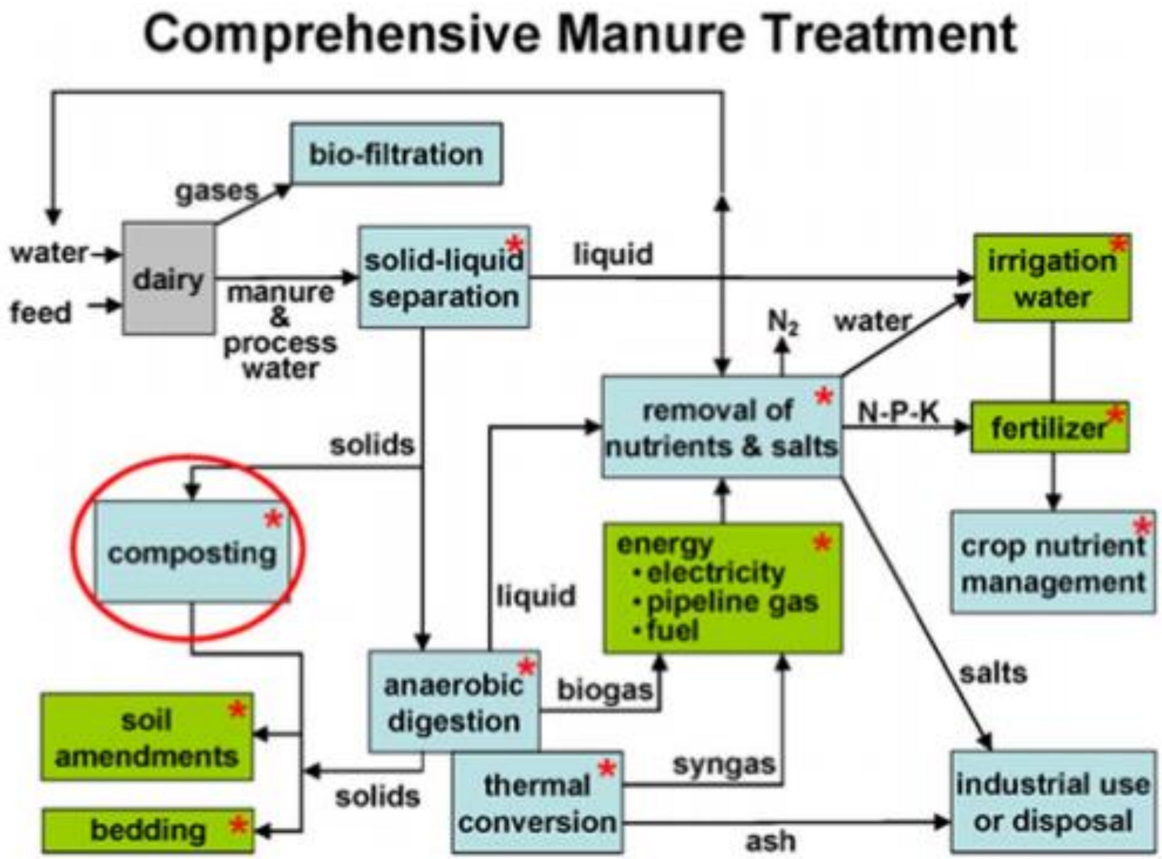
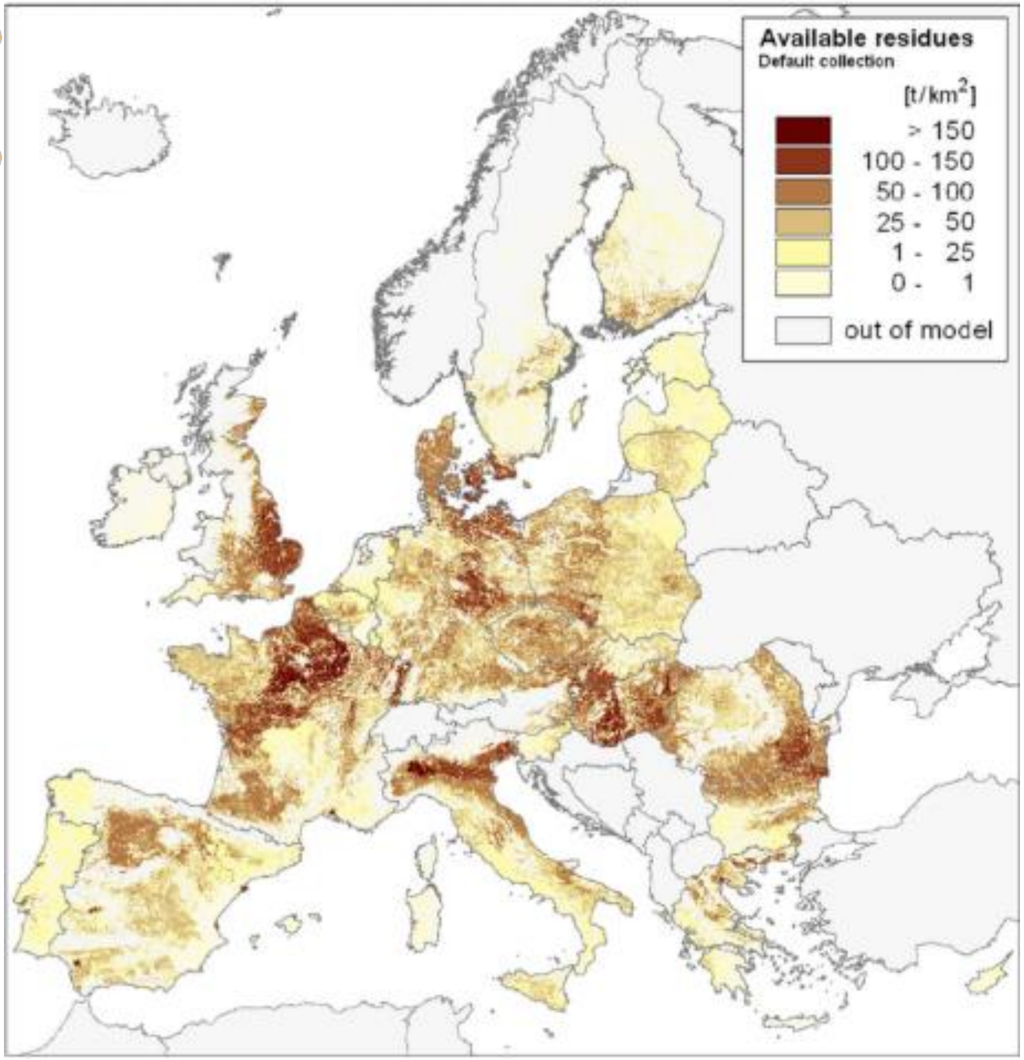



**Fig. 10.** Model of integrated biorefinery to produce compost, digestate and for recovering energy from a comprehensive poultry manure chain.
Source: Elaboration of the corresponding author.

https://doi.org/10.1016/j.rser.2018.02.041
Received 2 May 2017; Received in revised form 8 November 2017; Accepted 28 February 2018
Available online 16 March 2018

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




Mapeamento de disponibilidade de resíduos para aproveitamento energético

Fig. 3. Agricultural straw residues per square kilometer potentially available for energy recovery and biorefinery purposes in the European Union. Source:[37].

https://doi.org/10.1016/j.rser.2018.02.041
Received 2 May 2017; Received in revised form 8 November 2017; Accepted 28 February 2018
Available online 16 March 2018

# Mapeamento de disponibilidade de resíduos para aproveitamento energético

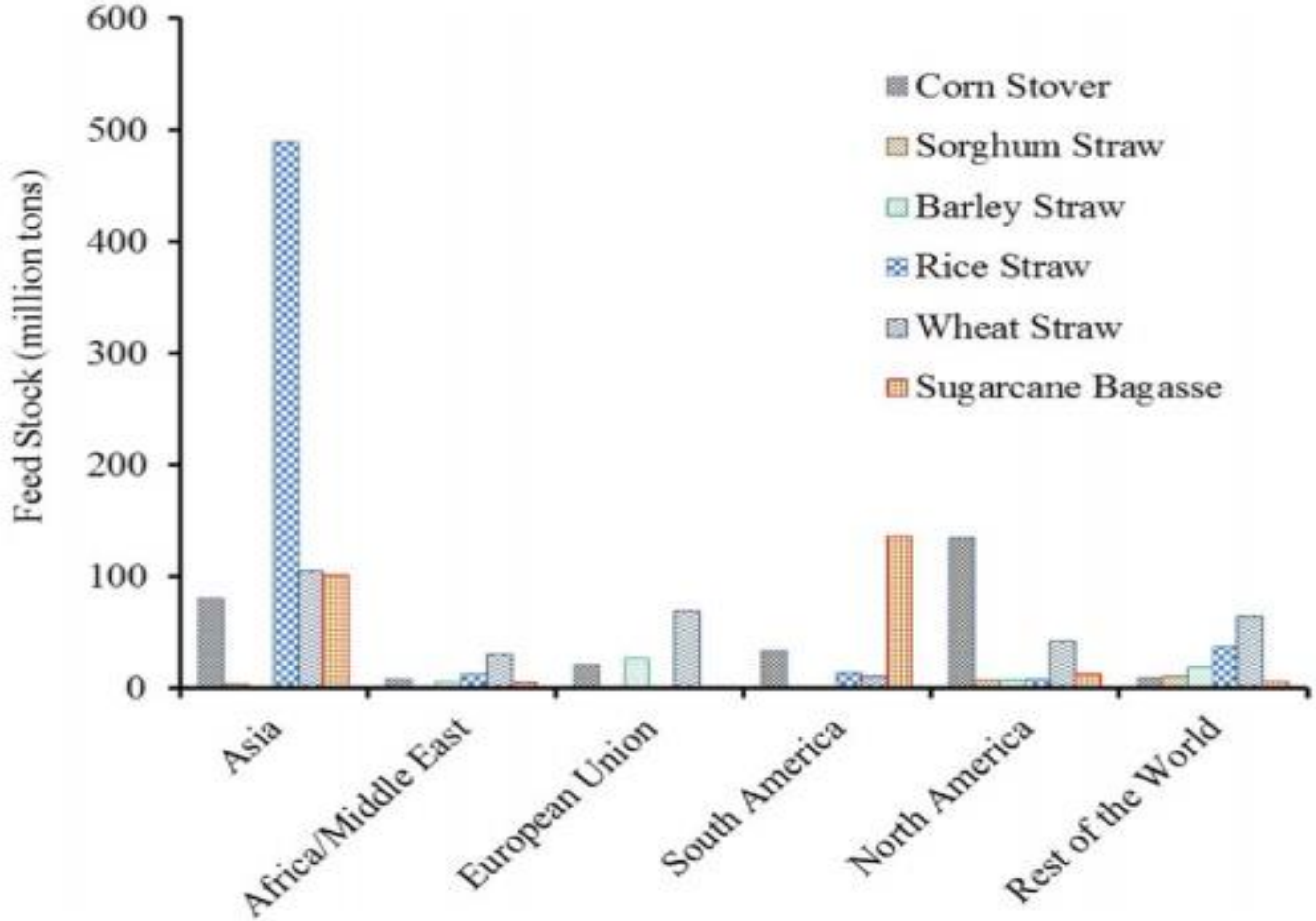
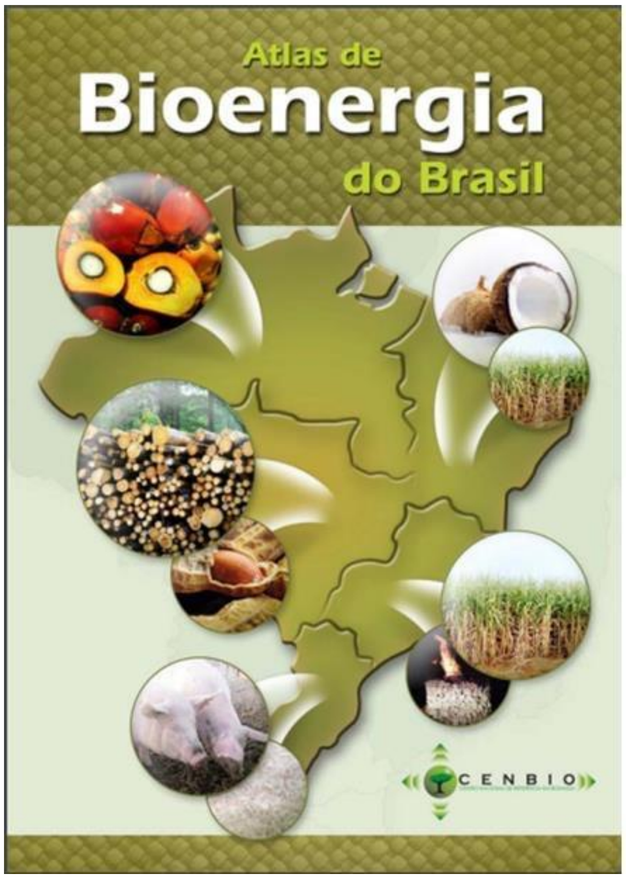
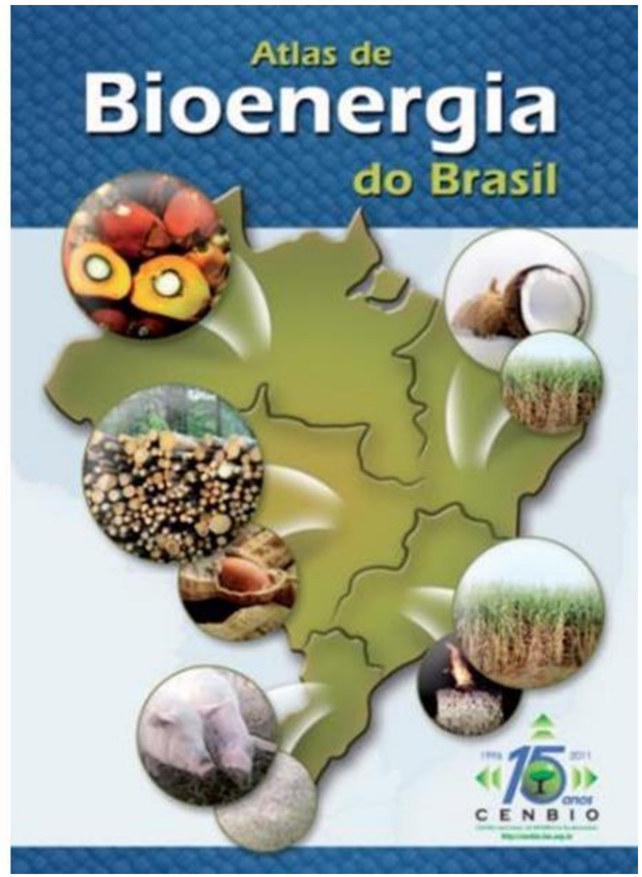



**Fig. 2.** Potential availability of selected agricultural residues in 2015/16 (Data source: [57]).

https://doi.org/10.1016/j.rser.2018.02.022
Received 10 December 2016; Received in revised form 8 October 2017; Accepted 23 February 2018
Available online 07 March 2018


Atlas de
Bioenergia
do Brasil
CENBIO

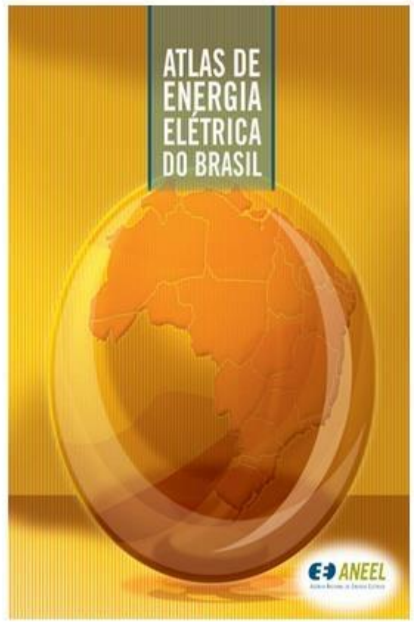
2009

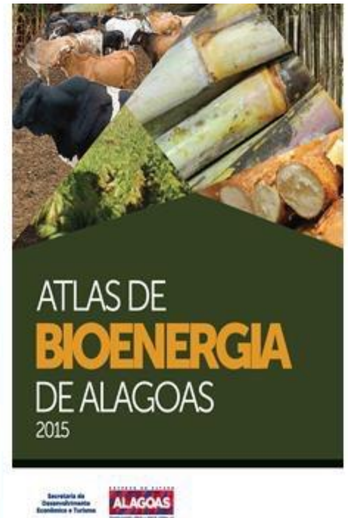

Atlas de
Bioenergia
do Brasil
15 anos
CENBIO

2012

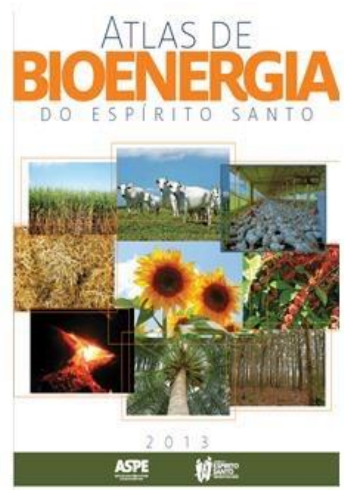
IEE USP

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

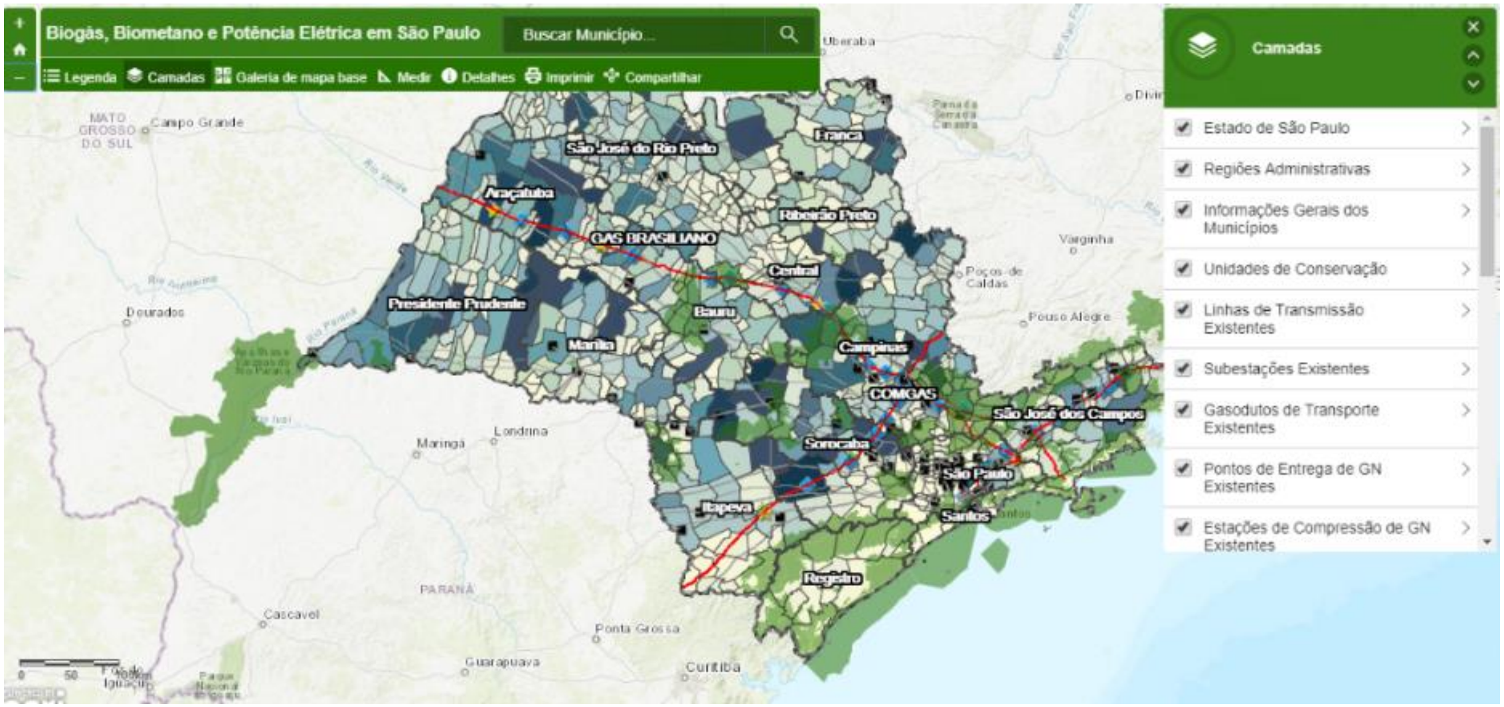







# Interactive Maps for biogas, biomethane & electricity potentials in São Paulo State - 2019




Research Centre for Gas Innovation
cleaner energy for a sustainable future

http://gbio.webhostusp.sti.usp.br/?q=pt-br/noticia/rcgi-lan%C3%A7a-mapas-interativos-com-o-potencial-de-gera%C3%A7%C3%A3o-de-energia-do-biog%C3%A1s-em-sp

# PROJETO P&D – CESP – ANEEL – 2018-2020

**COGERAÇÃO NO SETOR DE AÇÚCAR E ALCOOL**

OTIMIZAÇÃO DO PROCESSO DE PRODUÇÃO
BUSINESS PLAN PARA COMERCIALIZAÇÃO DA ELETRICIDADE

**ATLAS DE BIOENERGIA DO ESTADO DE SÃO PAULO**

**PROF DOREL SOARES RAMOS (EPUSP/USP)**
**PROF SUANI COELHO (GBIO/IEE/USP)**
**PROF PEDRO DIAS (UNESP)**

# Usos Finais da Biomassa - Energia

- Produção de energia
  - Cogeração com bagaço de cana-de-açúcar e residuos em geral
  - Pellets de resíduos de madeira
  - Biogás em aterros, ETEs, agro-industrias e na propriedades rurasi
  - "Cooking stoves"(Traditional biomass)

- Biocombustíveis (liquidos)
  - Etanol (cana-de-açúcar, milho, beterraba)
  - Biodiesel (palma, soja, mamona, canola, gordura animal, etc)

# Biomassa Moderna *vs* Biomassa Tradicional (Karekezi, Lata & Coelho, 2004)

- Tecnologias tradicionais de uso da biomassa ("biomassa tradicional"):
  - Combustão direta (ineficiente) de madeira, lenha, carvão vegetal, resíduos agrícolas, resíduos de animais e urbanos.
  - Usos: cocção, aquecimento, secagem e produção de carvão.
  - Principalmente Africa, Asia, AL/C

- Tecnologias "aperfeiçoadas" de uso da biomassa ("biomassa aperfeiçoada"):
  - Tecnologias mais eficientes de combustão direta de biomassa (fogões e fornos).

# Biomassa Moderna vs Biomassa Tradicional (Karekezi, Lata & Coelho, 2004)



- <u>Tecnologias modernas de uso da biomassa ("biomassa moderna"):</u> tecnologias avançadas de conversão de biomassa
  - Geração de eletricidade a partir de bagaco de cana, madeira e resíduos rurais/urbanos
  - Uso de biocombustíveis – Programa do Álcool no Brasil e EUA



# Situação Mundial

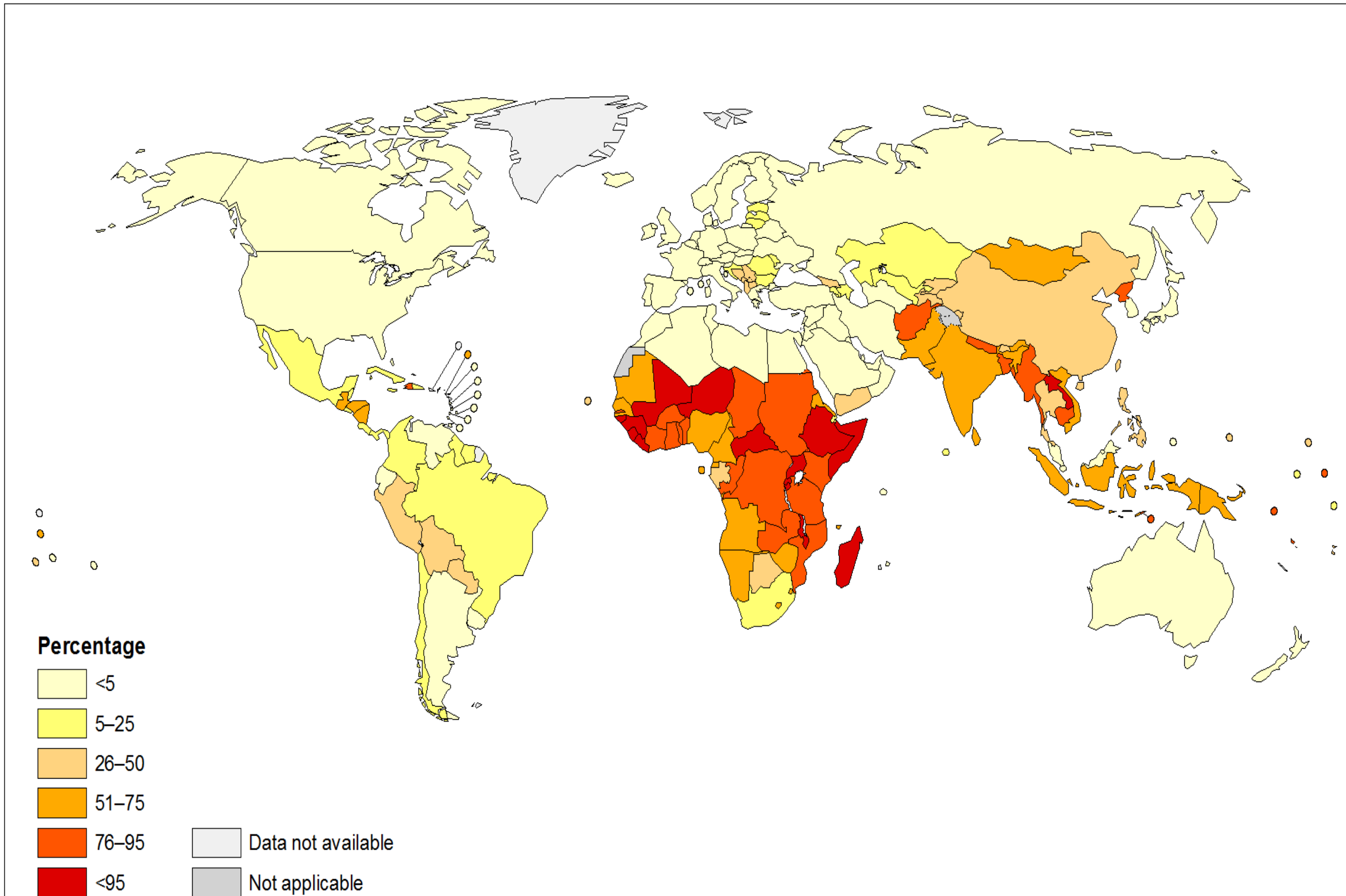
- 1,2 bilhões de pessoas sem acesso a eletricidade no mundo
- 2,7 bilhões de pessoas – biomassa de desmatamento para aquecimento e cocção de alimentos (REN21,2016)
- 50% dos DC´s – 80% Africa Sub-Saariana
- Necessidade de garantir acesso à energia usando combustíveis modernos e limpos
- Grupo de trabalho do Secretario Geral da ONU - United Nations Secretary General Advisory Group on Energy and Climate Change (AGECC)
- Criação da "United Nations Energy Access Facility – UN-EAF"

IEE USP

# Desigualdade x uso de biomassa tradicional

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

## Population Cooking with Solid Fuels in 2010 (%)




The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted and dashed lines on maps represent approximate border lines for which there may not yet be full agreement.

Data Source: World Health Organization
Map Production: Public Health Information and Geographic Information Systems (GIS)
World Health Organization

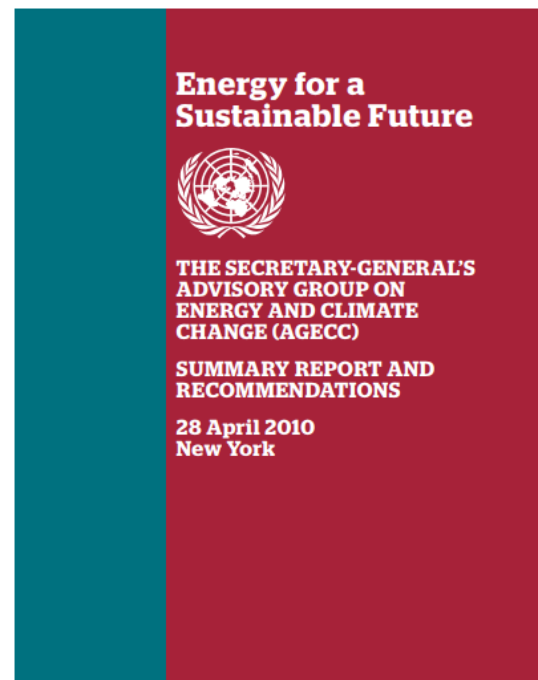
World Health Organization

# Situação Mundial

- United Nations Secretary General Advisory Group on Energy and Climate Change (AGECC) - https://www.unido.org/our-focus/cross-cutting-services/green-industry/partnerships/agecc-group

- **2013 – SE4ALL – Sustainable Energy for All**

**https://www.seforall.org/about-us**


Energy for a Sustainable Future

THE SECRETARY-GENERAL'S ADVISORY GROUP ON ENERGY AND CLIMATE CHANGE (AGECC)

SUMMARY REPORT AND RECOMMENDATIONS

28 April 2010
New York

# BIOENERGY CONTRIBUTING TO ACHIEVE THE SUSTAINABLE DEVELOPMENT GOALS


Established in 2015 at the United Nations

Each goal has specific targets to be achieved over the next 15 years (2030)

# Energy Access Worldwide



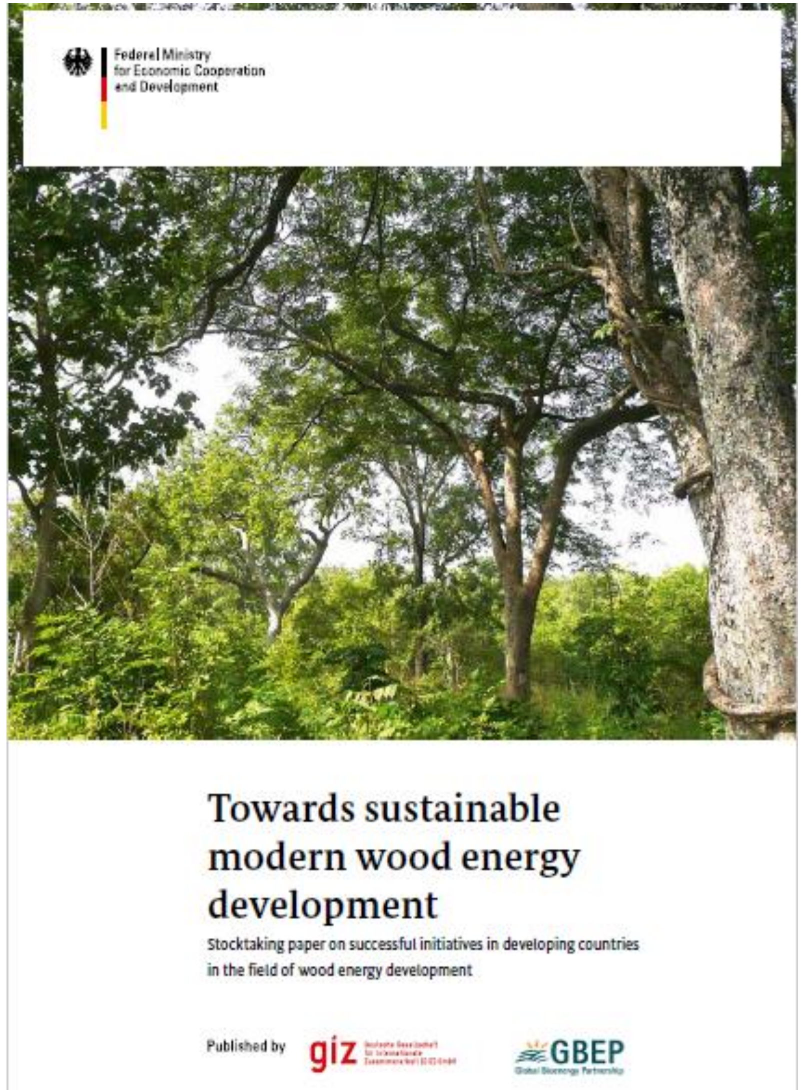
**Table 1**
Number and share of people without access to modern energy services in selected countries (2008). *Source* OECD/IEA (2011).

| Countries/regions | Without access to electricity | | Relying on the traditional use of biomass for cooking | |
|---|---|---|---|---|
| | Population (million) | Share of population (%) | Population (million) | Share of population (%) |
| **Africa** | **587** | **58** | **657** | **65** |
| Nigeria | 76 | 49 | 104 | 67 |
| Ethiopia | 69 | 83 | 77 | 93 |
| DR of Congo | 59 | 89 | 62 | 94 |
| Tanzania | 38 | 86 | 41 | 94 |
| Kenya | 33 | 84 | 33 | 83 |
| Other sub-Saharan Africa | 310 | 68 | 335 | 74 |
| North Africa | 2 | 1 | 4 | 3 |
| **Developing Asia** | **675** | **19** | **1921** | **54** |
| India | 289 | 25 | 836 | 72 |
| Bangladesh | 96 | 59 | 143 | 88 |
| Indonesia | 82 | 36 | 124 | 54 |
| Pakistan | 64 | 38 | 122 | 72 |
| Myanmar | 44 | 87 | 48 | 95 |
| Rest of developing Asia | 102 | 6 | 648 | 36 |
| **Latin America** | **31** | **7** | **85** | **19** |
| **Middle East** | **21** | **11** | **0** | **0** |
| **DCs** | **1314** | **25** | **2662** | **51** |
| **World** | **1317** | **19** | **2662** | **39** |


Smith, K., 2016 - ***International Conference on LPG: Catalyst of Social Change*** - Indian Ministry of Petroleum and Natural Gas. Bhubaneswar, Odisha

IEE USP

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


Federal Ministry for Economic Cooperation and Development

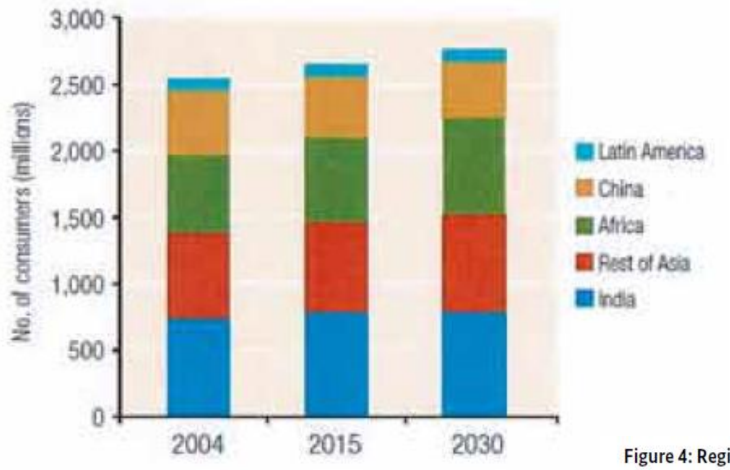
# Towards sustainable modern wood energy development

Stocktaking paper on successful initiatives in developing countries in the field of wood energy development

Published by giz GBEP

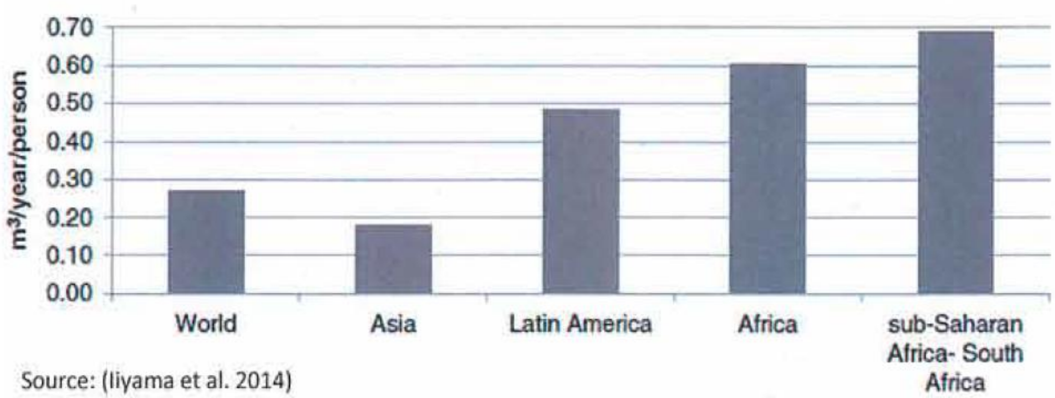
# Uso de lenha e carvão vegetal

**Figure 3: Number of people relying on biomass energy**




Source: (IEA 2006)

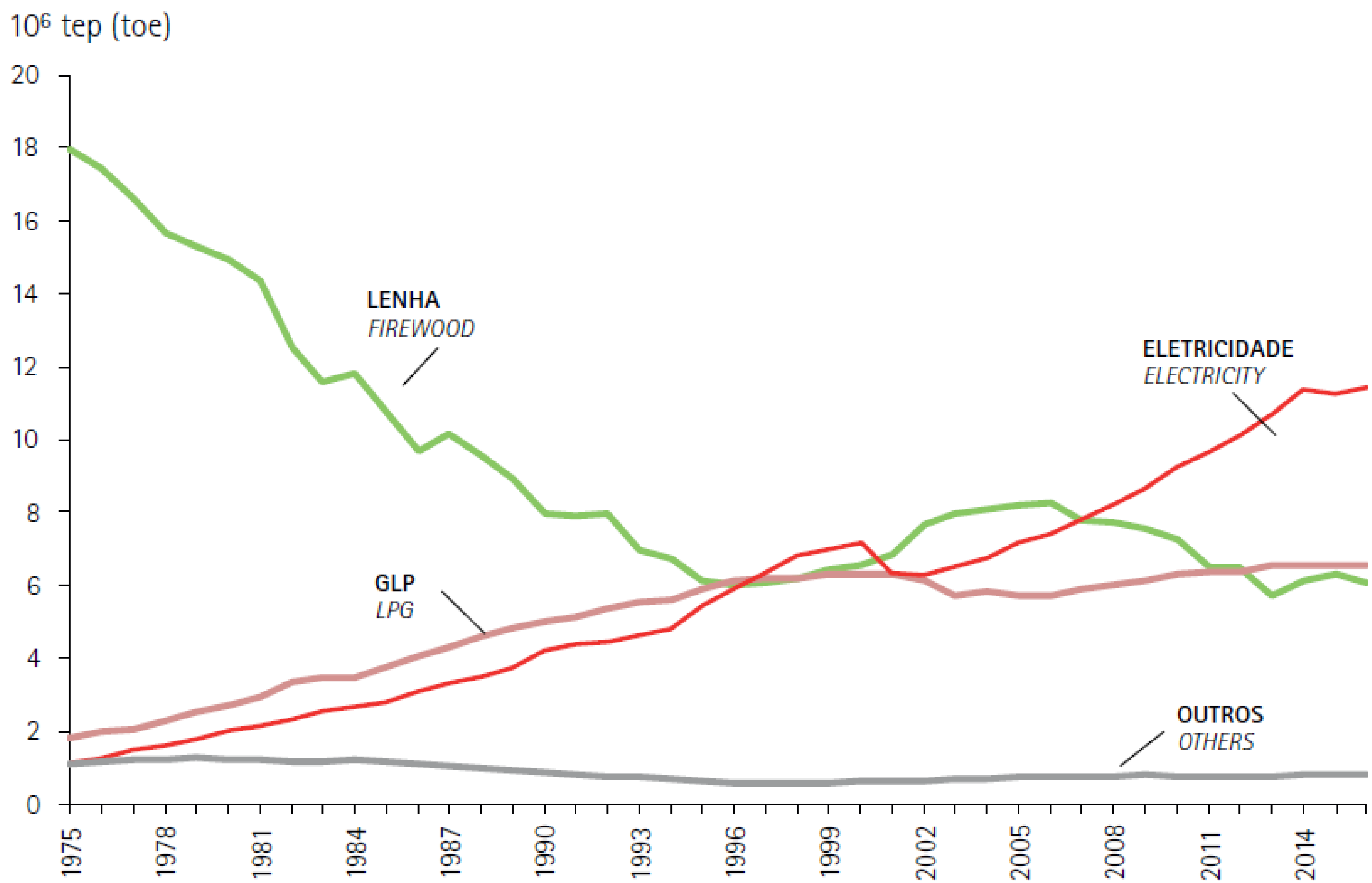
**Figure 4: Regional comparison of per capita woodfuel consumption in 2011**




Source: (Iiyama et al. 2014)

Source: GIZ/GBEP – Towards sustainable modern wood energy development, https://www.giz.de/fachexpertise/downloads/giz2015-en-report-wood-energy.pdf

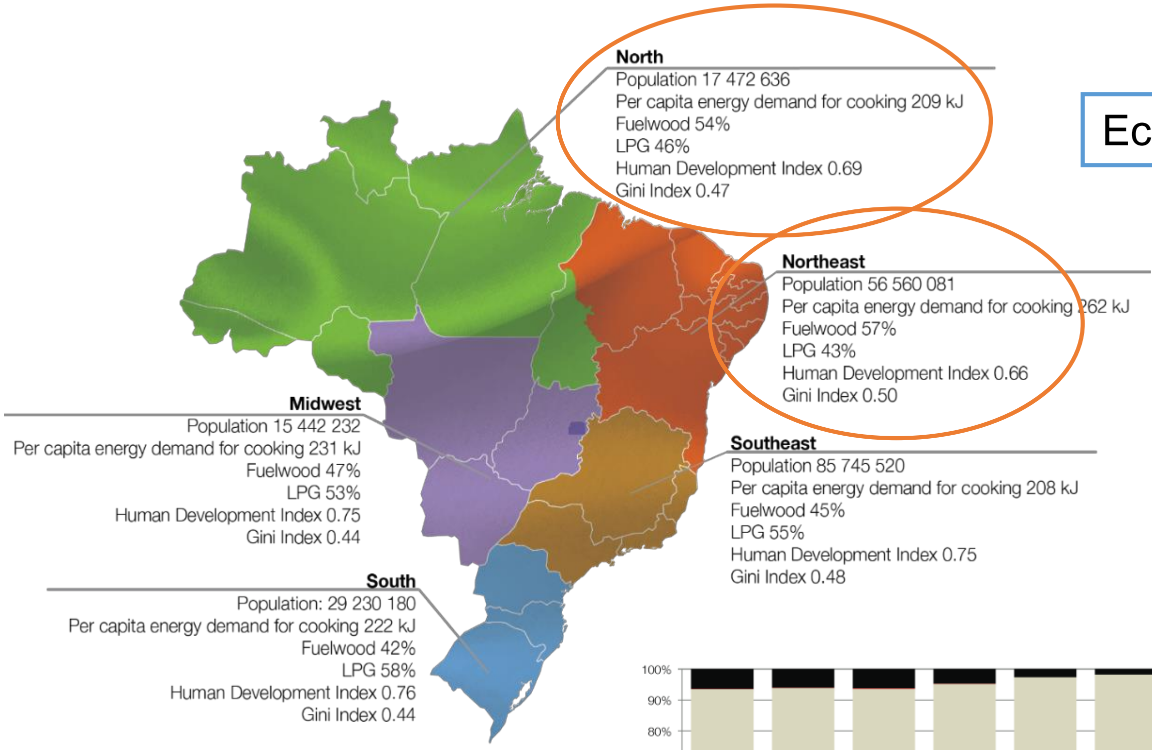
# Consumo de energia residencial no Brasil

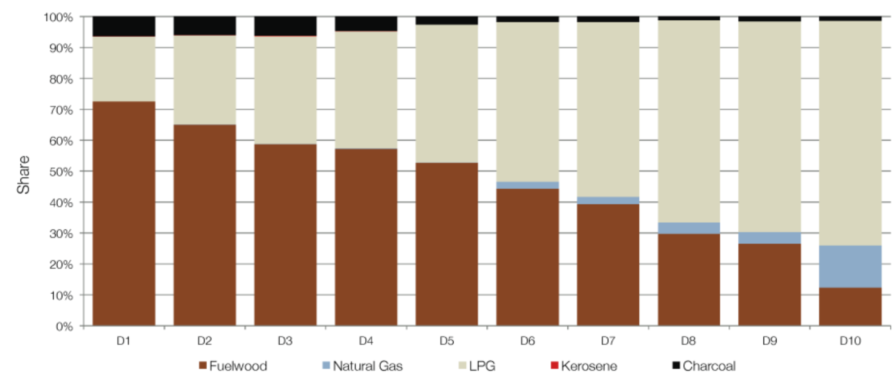



Source: EPE (2017). Balanço Energético Nacional (BEN)

# Desigualdade nas regiões

Ecopa Project – FAPESP/ANR

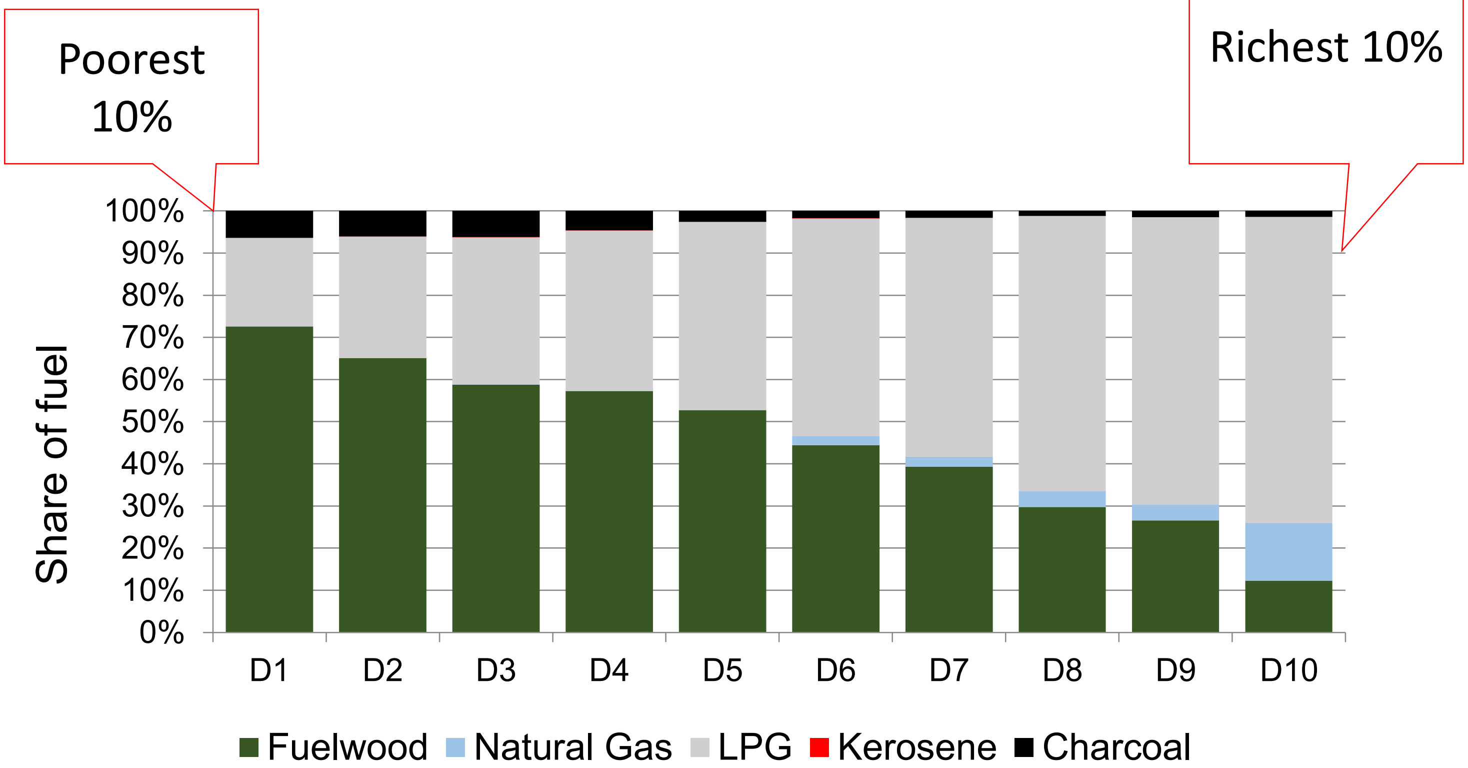



Source: Prepared by the authors based on data from MME (2010-2014) and Uchôa (2014)

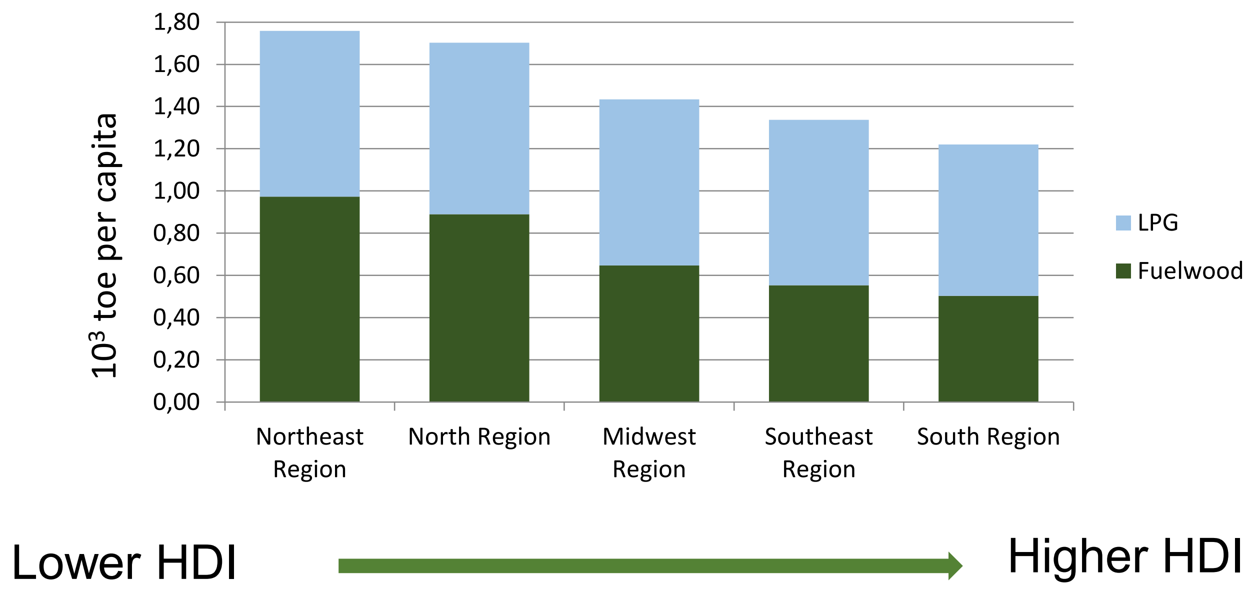
# Residential cooking fuel share

# per income decile in Brazil (2013)




Source: Sanches-Pereira A, Tudeschini LG, Coelho ST. Evolution of the Brazilian residential carbon footprint based on direct energy consumption. Renew Sustain Energy Rev 2016;54:184–201.

# Per capita consumption of fuelwood and LPG in Brazil for cooking per region in 2013




Source: Sanches-Pereira A, Tudeschini LG, Coelho ST. Evolution of the Brazilian residential carbon footprint based on direct energy consumption. Renew Sustain Energy Rev 2016;54:184–201.

# *Bioenergy and Sustainable Development*

**Reduce greenhouse gas emissions**.

**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**.

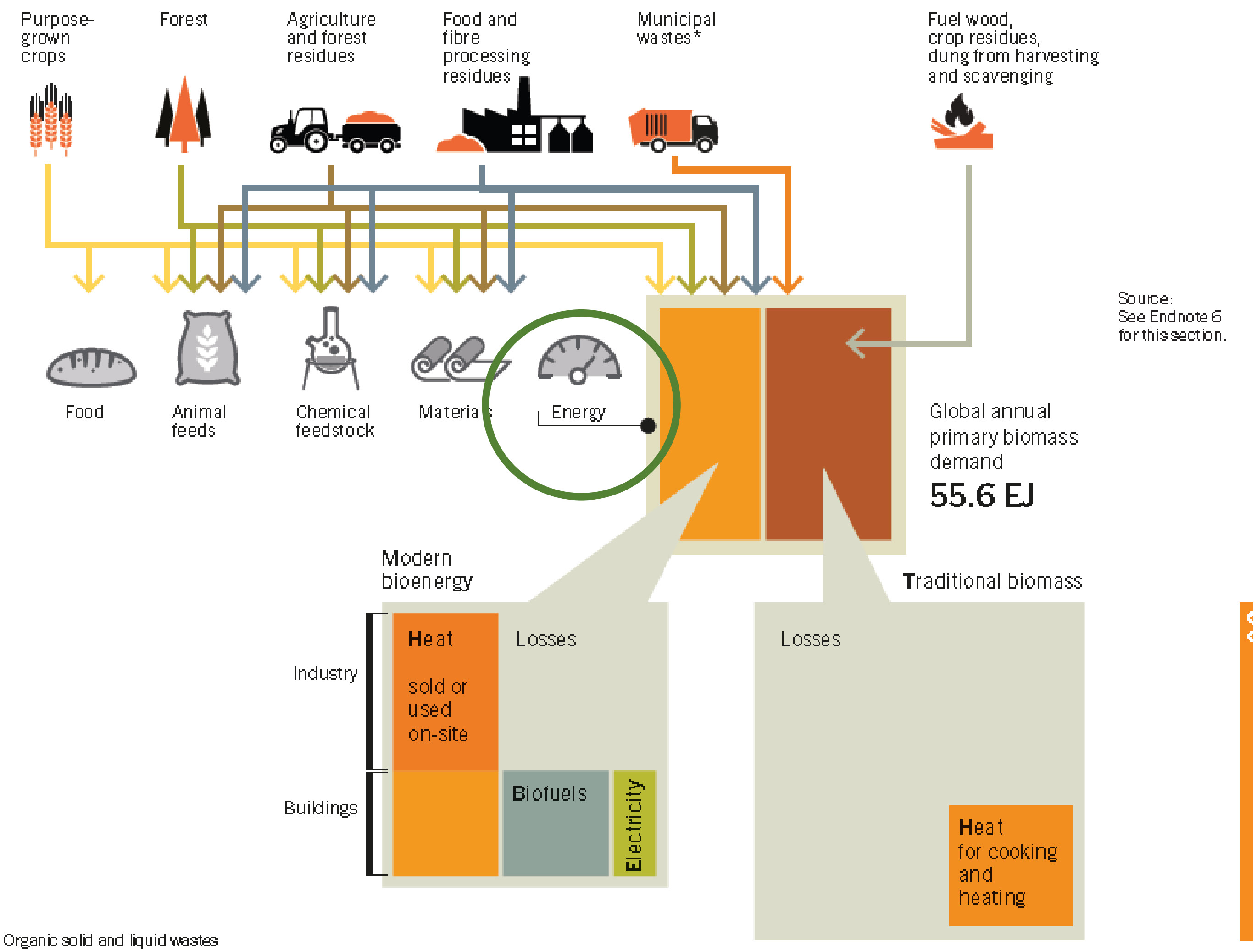
**Complement efforts to improve waste management and air and water quality**.

Help improve **modern energy access for some of the 2.7 billion people who lack it (both for heating, cooking and electricity**).

Source: IEA, 2017 – Bioenergy Technology Roadmap

# Biomass resources

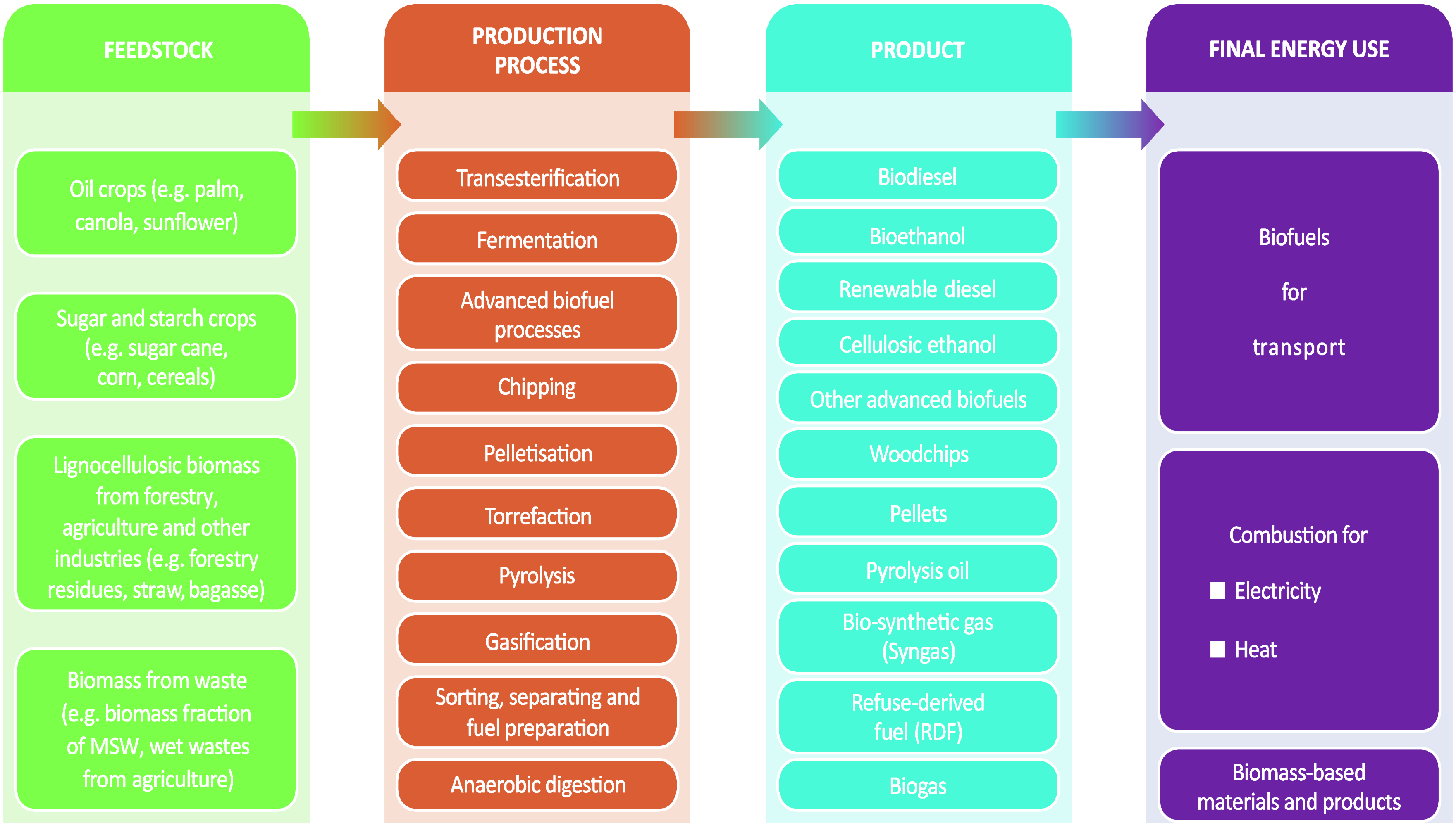
**Figure 5.** Biomass Resources and Energy Pathways




*Organic solid and liquid wastes

Source: REN 21 Global Status Report (2018)

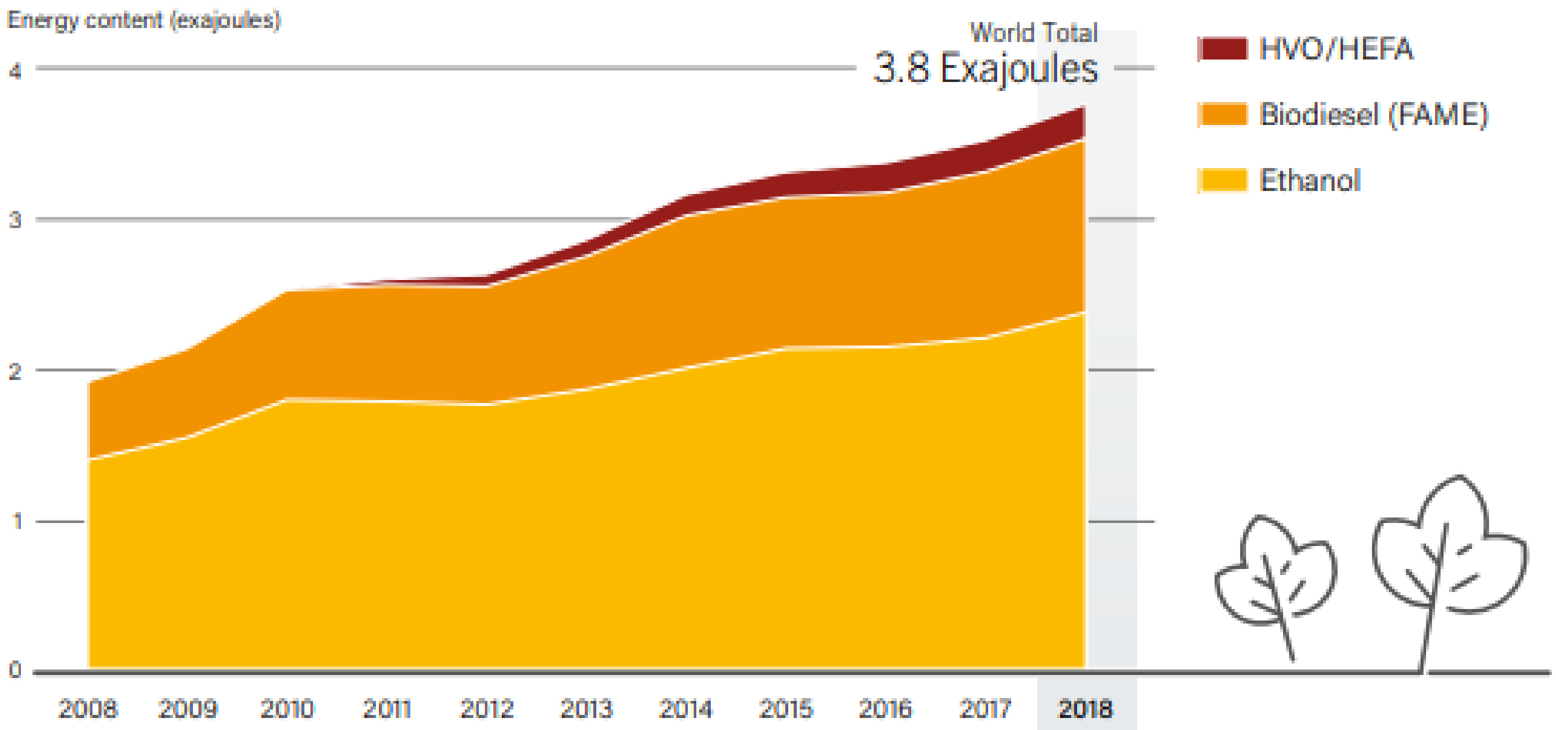
# Potential configurations of bioenergy pathways: From biomass to final energy use




Source: IEA, 2017 – Bioenergy Technology Roadmap

# Bioenergia no mundo/biocombustiveis

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



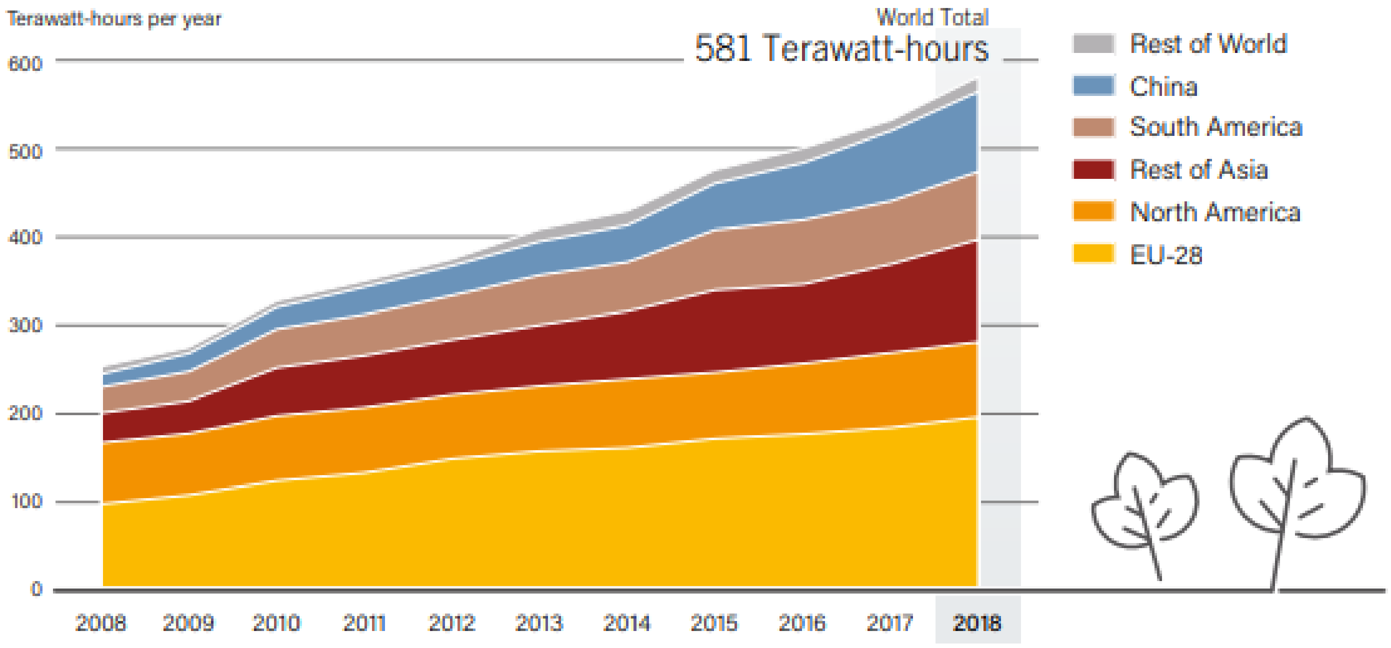

Note: HVO = hydrotreated vegetable oil; HEFA = hydrotreated esters and fatty acids; FAME = fatty acid methyl esters

Source: See endnote 52 for this section.

Source: REN 21 Global Status Report (2019)

# Bioenergia no mundo/eletricidade

FIGURE 19. Global Bioelectricity Generation, by Region, 2008-2018




Source: See endnote 32 for this section.

Source: REN 21 Global Status Report (2019)

TABLE 3. Renewable Electricity Generating Technologies, Costs and Capacity Factors, 2018

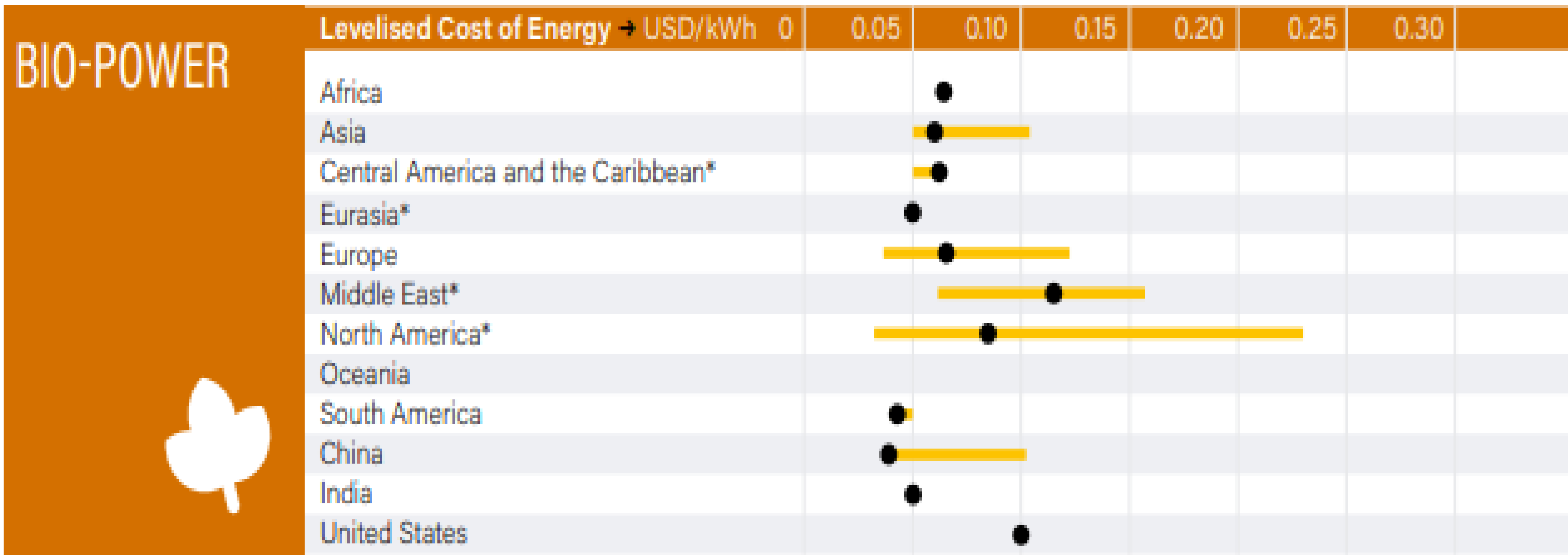
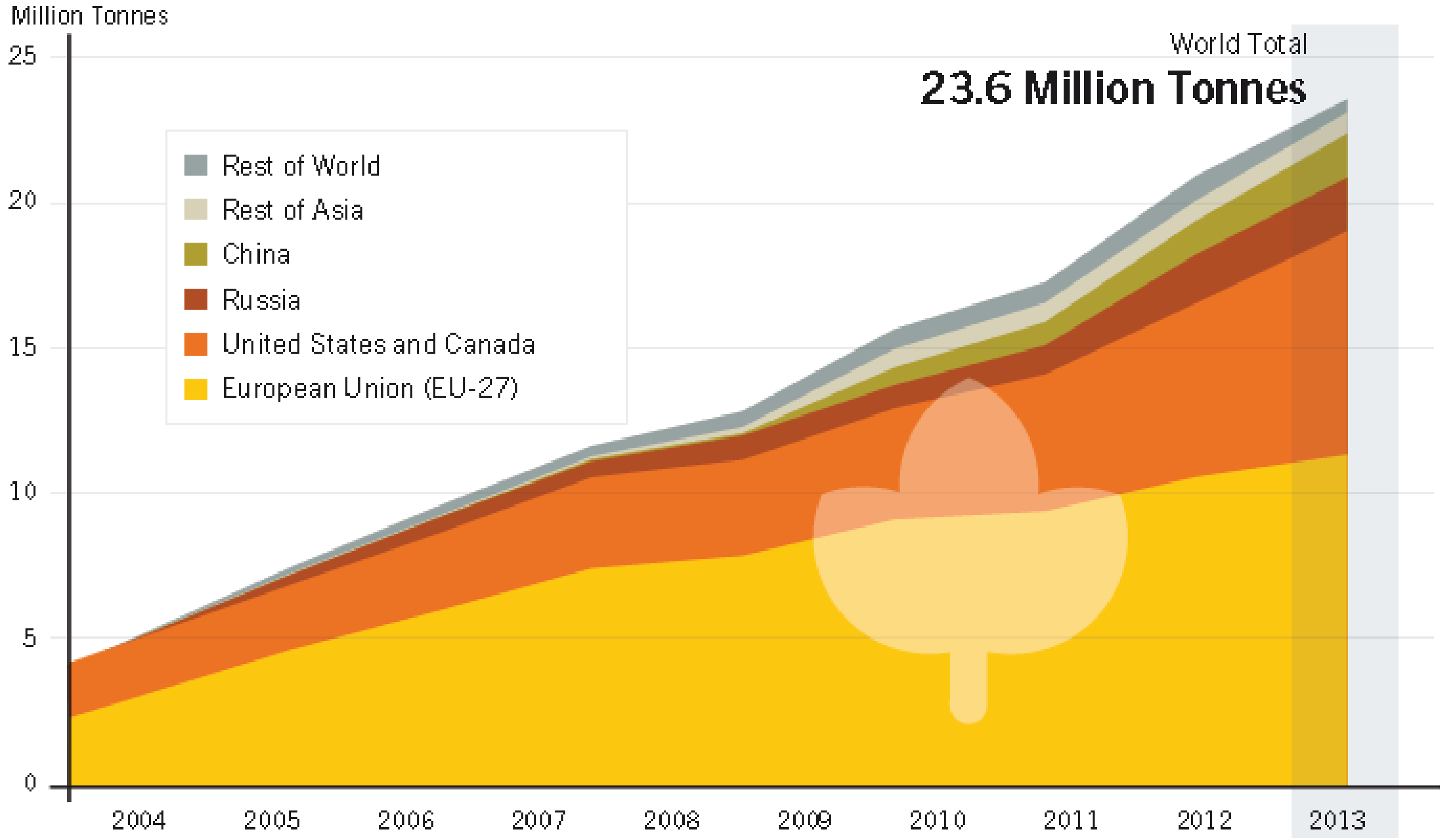
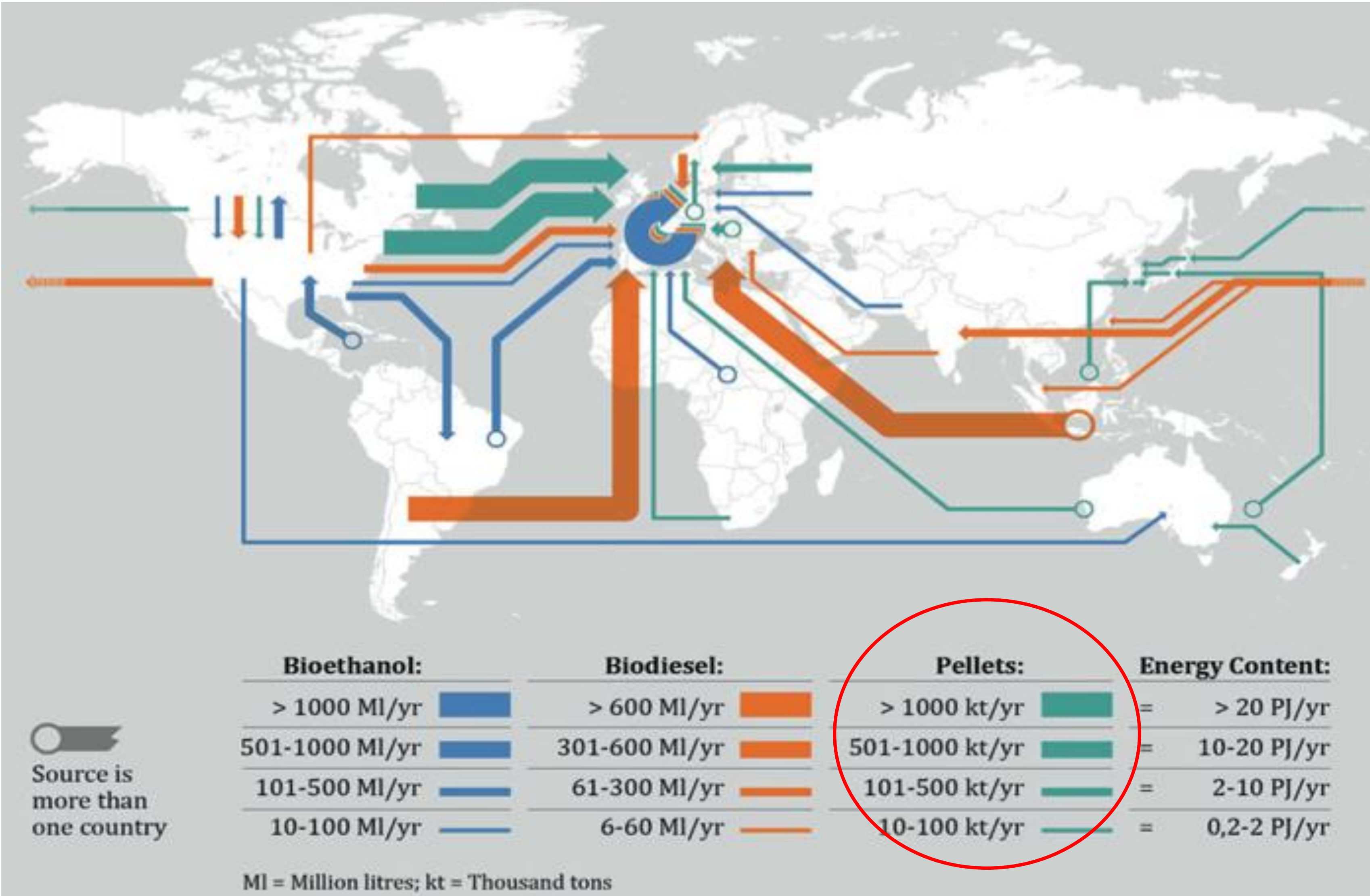


**Figure 7.** Wood Pellet Global Production, by Country or Region, 2000–2013



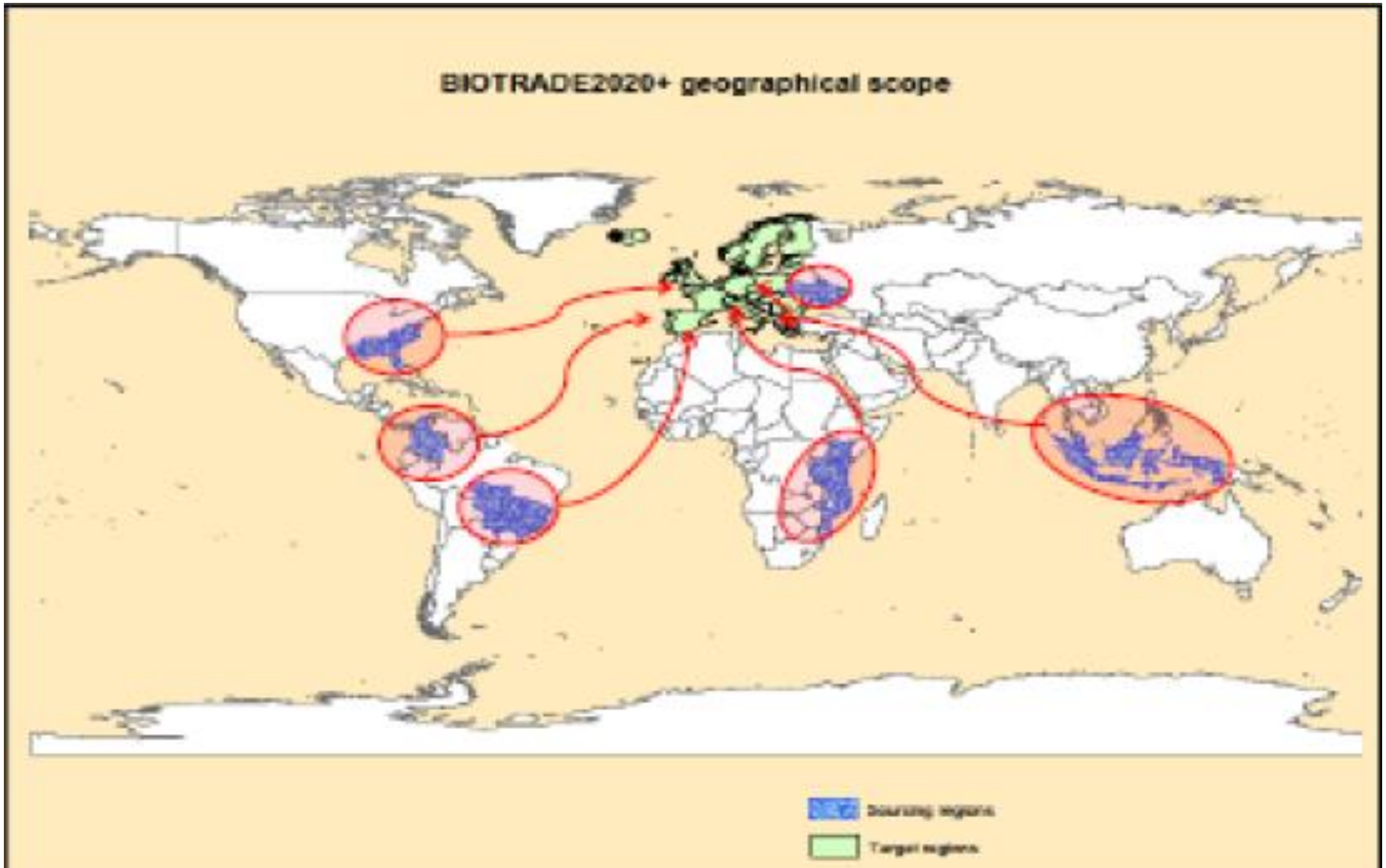

Source: see Endnote 60 for this section.



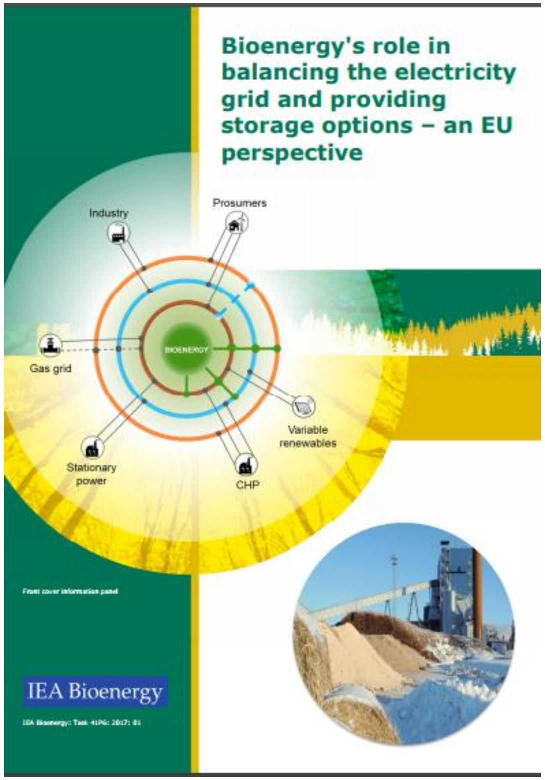

Fonte: REN21.Renewables 2012 – Global Status Report

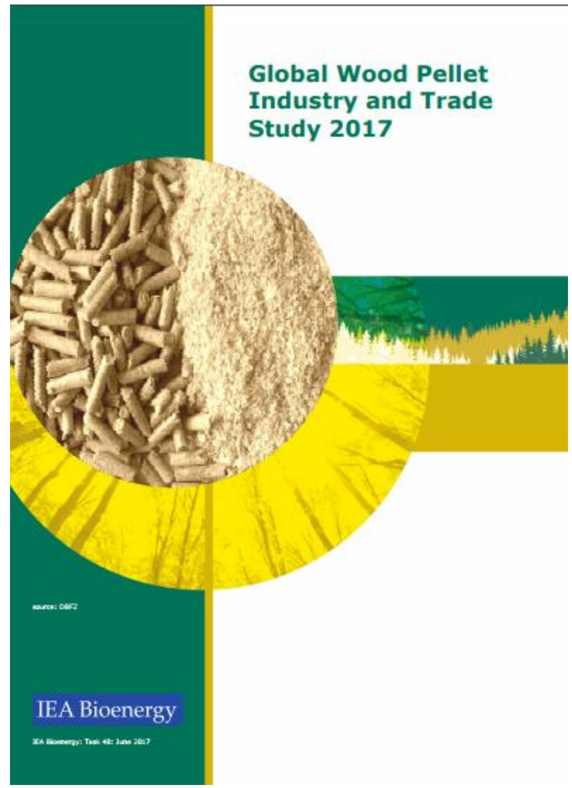
# Projeto *BioTrade2020plus*

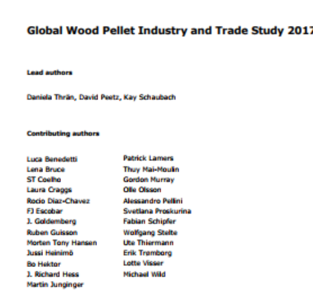
*Supporting a Sustainable European Bioenergy Trade Strategy BioTrade2020plus*




Disponivel em http://www.biotrade2020plus.eu/images/workshop-vienna/1_BioTrade2020-Workshop_Biomass_Trade_Vienna_150603_CENER.pdf



**Global Wood Pellet Industry and Trade Study 2017**

**Lead authors**

Daniela Thrän, David Peetz, Kay Schaubach

**Contributing authors**

| | |
|---|---|
| Luca Benedetti | Patrick Lamers |
| Lena Bruce | Thuy Mai-Moulin |
| ST Coelho | Gordon Murray |
| Laura Craggs | Olle Olsson |
| Rocio Diaz-Chavez | Alessandro Pellini |
| FJ Escobar | Svetlana Proskurina |
| J. Goldemberg | Fabian Schipfer |
| Ruben Guisson | Wolfgang Stelte |
| Morten Tony Hansen | Ute Thiermann |
| Jussi Heinimö | Erik Tromborg |
| Bo Hektor | Lotte Visser |
| J. Richard Hess | Michael Wild |
| Martin Junginger | |

http://www.ieabioenergy.com/wp-content/uploads/2017/02/IEA-Bioenergy-bio-in-balancing-grid_master-FINAL.pdf

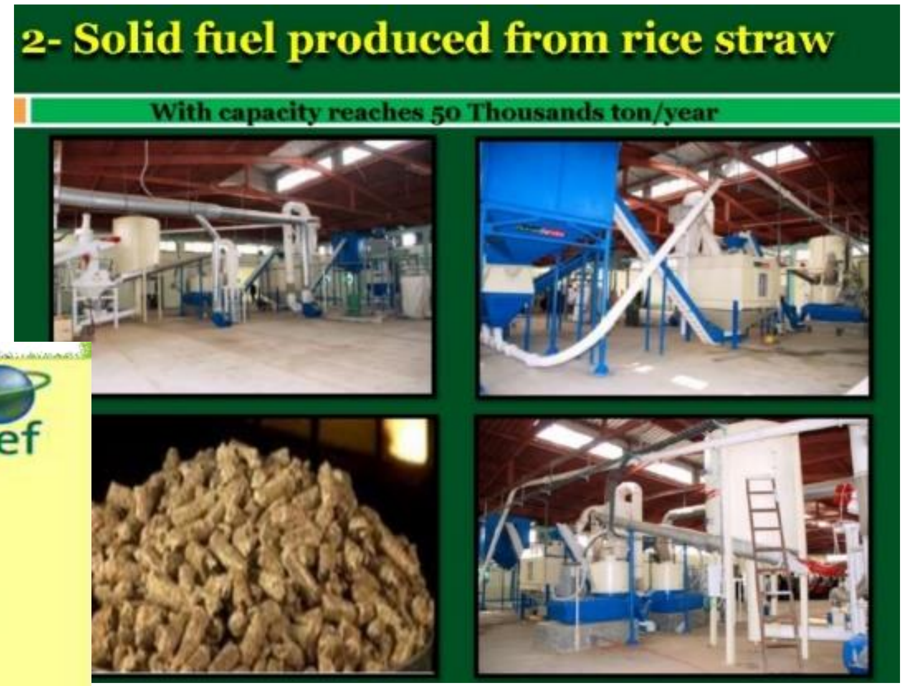
http://task40.ieabioenergy.com/wp-content/uploads/2013/09/IEA-Wood-Pellet-Study_final-2017-06.pdf

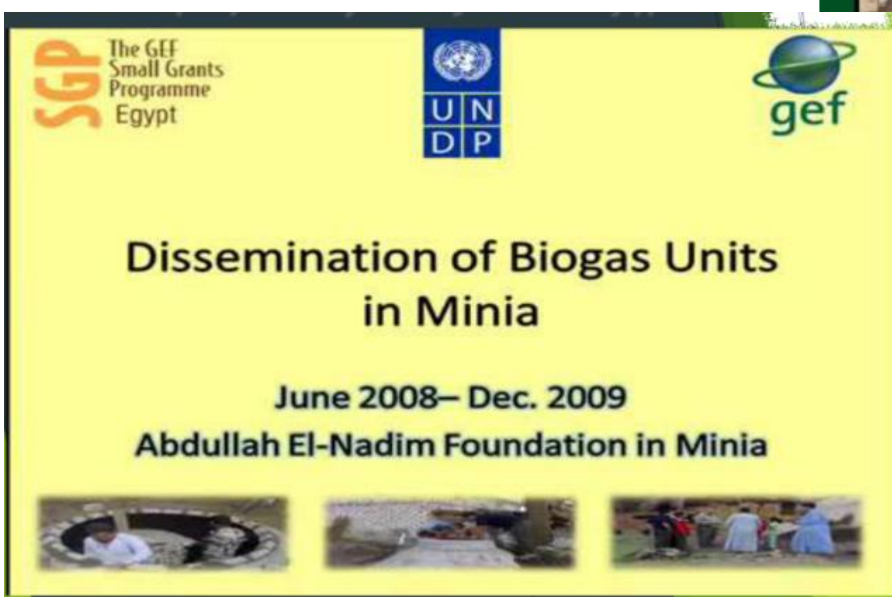
# Bioenergia nos países em desenvolvimento

Estudos de caso

# EGITO

GBEP
Global Bioenergy Partnership

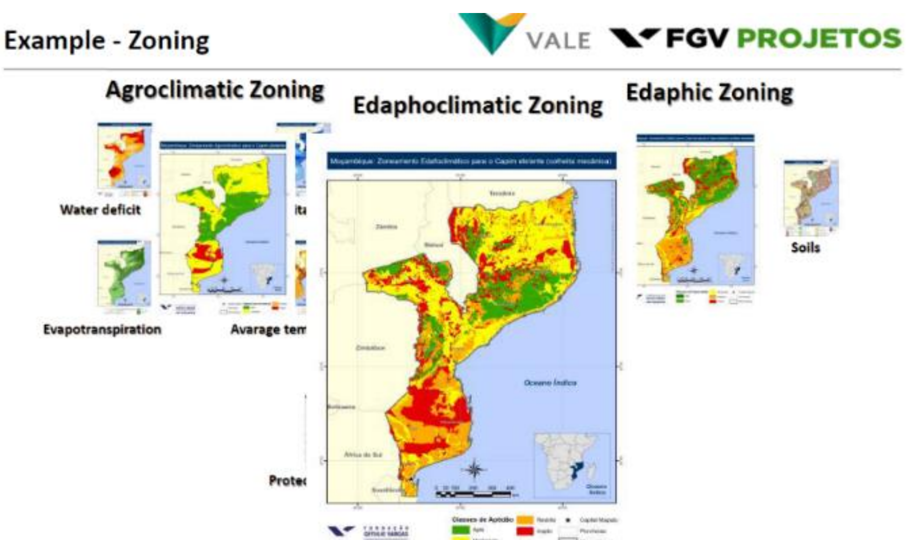



Prof . Dr. Ahmed Abd El-Ati Ahmed
Egypt - GBEP Focal Point

# MOÇAMBIQUE


República de Moçambique
Ministério da Agricultura
Zoneamento Agroecológico
Resultados do País, excepto Maputo
Apresentação à
de Bioenergia
Maputo, 06 Maio de 2014


Example - Zoning
VALE
FGV PROJETOS
Agroclimatic Zoning
Edaphoclimatic Zoning
Edaphic Zoning
Water deficit
Evapotranspiration
Soils


Mozambique: Track Field
Indian Ocean

# SUDÃO

## Practical Experience

- **Sudan has started an ambitious non-hydrous bio-ethanol production plan**
- The first bio-ethanol plan in Sudan (2009)
- **High value added product with high export potential**
- Brazilian technology ; State of the art, fully computerized plant
- **Uses molasses as feedstock with flexibility to use juice**
- **Production Capacity:** 200,000L/day, 65 m L/year.
- **Market: Domestic - 10%; Export - 90% (to EU)**

## Ethanol Production

**Product**

- Ethanol – Anhydrous Alcohol

**By products**

- Yeast
- 2nd Grade Alcohol
- Vinasse
- $CO_2$ (Carbon Dioxide)

# QUÊNIA

Solar PV (Horticulture - Tambuzi, Kenya)

Training Workshop - Nairobi, Kenya
June, 2017

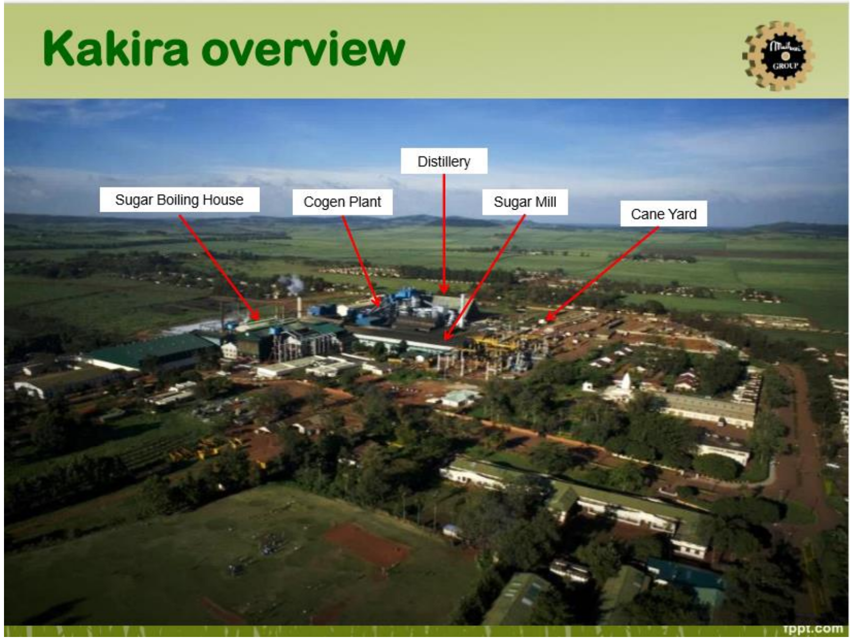
Stephen Karekezi
Director - AFREPREN/FWD
Nairobi, Kenya

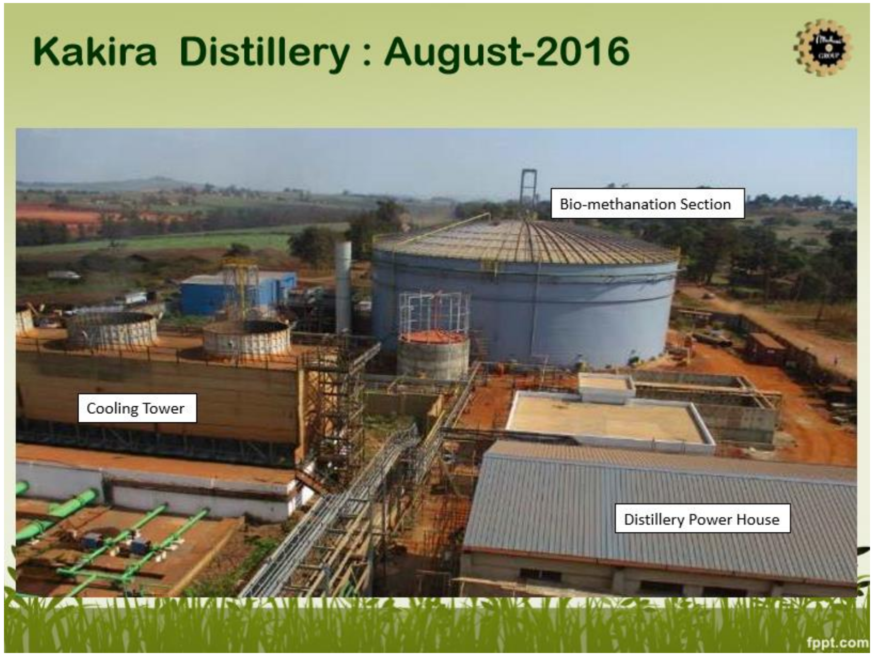
## Energy Security for Agro-industry Kenya

Biogas (PJ Dave Flowers, Kenya)

# UGANDA

Kakira Sugar Ltd – Etanol de cana + planta de biogas de vinhaça (0,4MW)



# Energy supply for households around the plant Uganda

IEE USP

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


## UNIDO/UNEP/GEF Project

**Generation and Delivery of Renewable Energy Based Modern Services in Cuba - The case of Isla de la Juventud**

- **Wood gasification for power production**


Source: S. Coelho, Project Technical Reviewer - 2014

# Cogen for Africa Project



Source: Coelho, S.T., Project Mid Term Reviewer, 2011

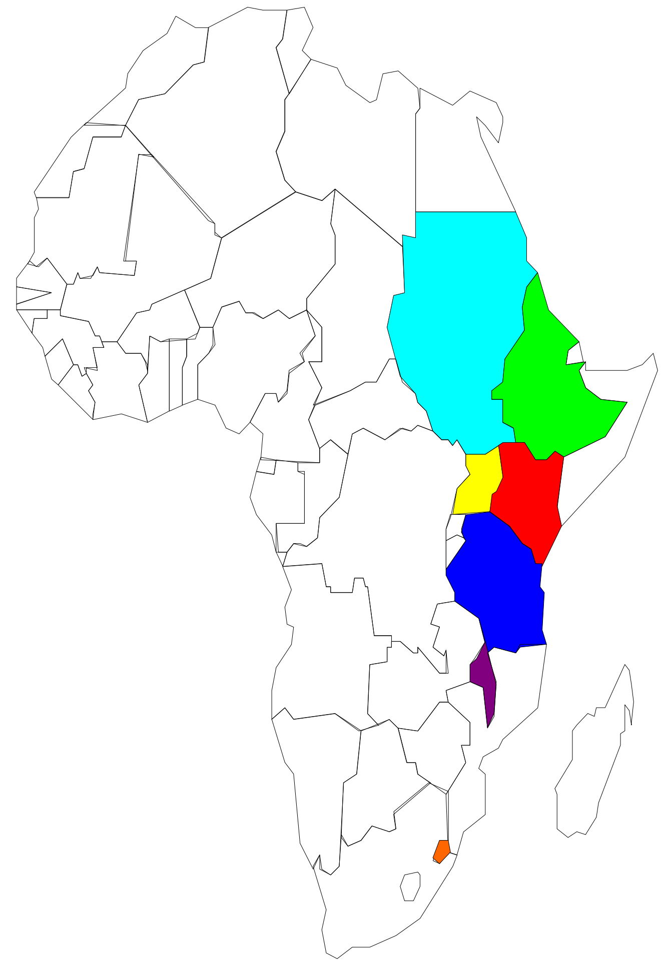
# Cogeneration for Africa- Overview

- To build on success of Mauritius & relevant elements of EC-supported Cogen Asia initiative

- Initial 6 year phase to cover 7 countries which have endorsed project (Kenya, Uganda, Tanzania, Sudan, Ethiopia, Malawi and Swaziland) – later phases could expand to other regions of Africa

- Established network of national coordinating centres/national experts willing to play a key role in promoting cogeneration

- Overall coordination provided by AFREPREN/FWD Regional Cogen Project Office



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


***Africa Sub Saariana***

***Cogen for Africa***

***Projeto GEF/UNEP/Nairobi***

KAKIR
A

LUGAZI

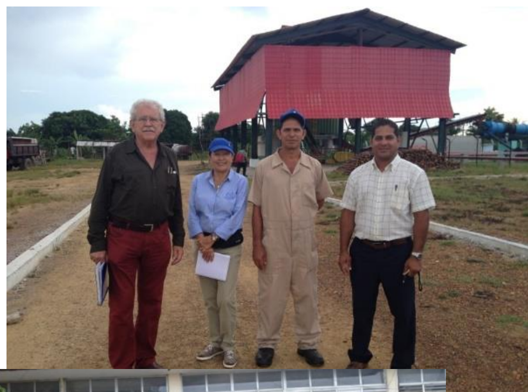
# Commissioned Cogen Investment – Kakira, Uganda


# Energy supply for households around the plant


## UNIDO/UNEP/GEF Project

**Generation and Delivery of Renewable Energy Based Modern Services in Cuba - The case of Isla de la Juventud**

- **Wood gasification for power production**




Source: S. Coelho, Project Technical Reviewer - 2014

# Biofuture Platform

biofuture platform
Kickstarting a global, advanced bioeconomy

An action-oriented, country-led, multistakeholder mechanism for **policy dialogue**

**Collaboration** among leading countries, organizations, academia and the private sector

Need to accelerate development and scale up deployment of modern sustainable low carbon alternatives to fossil based solutions in **transport, chemicals, plastics and other sectors**

Global fight against climate change, nurturing solutions in low carbon transport and the **bioeconomy**

To aid to countries to **reach their NDCs**

To contribute towards the **Sustainable Development Goals**, especially SDGs

biofuture platform
Kickstarting a global, advanced bioeconomy

ABOUT DECLARATIONS MEMBERS RESOURCES NEWS EVENTS GET INVOLVED

Argentina • Brazil • Canada • China • Denmark • Egypt • Finland • France • India • Indonesia • Italy • Morocco • Mozambique • Netherlands • Paraguay • Philippines • Sweden • United Kingdom • United States • Uruguay

# Matriz energética brasileira

Ministério de Minas e Energia

# BEN 2018

## Repartição da oferta interna de energia - OIE

**RENOVÁVEIS ▶ 43,2%**

| biomassa da cana | hidráulica[1] | lenha e carvão vegetal | lixívia e outras renováveis |
|---|---|---|---|
| 17,4% | 11,9% | 8,0% | 5,8% |




*[1] Inclui importação de eletricidade oriunda de fonte hidráulica*

**NÃO RENOVÁVEIS ▶ 56,8%**

| petróleo e derivados | gás natural | carvão mineral | urânio | outras não renováveis |
|---|---|---|---|---|
| 36,2% | 12,9% | 5,6% | 1,4% | 0,6% |





epe

BIOENERGY – A RENEWABLE ENERGY SOURCE

## To achieve Brazilian NDC - Paris Agreement


http://www.mma.gov.br/clima/convencao-das-nacoes-unidas/acordo-de-paris

# COP21 – Metas apresentadas pelo Brasil

PARIS2015
CONFERÊNCIA DA ONU SOBRE MUDANÇA CLIMÁTICA
COP21·CMP11

- Segundo o INDC apresentado e ratificado pelo Brasil junto à ONU, até 2030 o País precisa:
  - GEE: reduzir emissões de GEE em 43% (sobre base 2005);
  - Combustíveis: objetivo é aumentar a partic. dos biocombustíveis na matriz energética para 18%.
  - Energia Elétrica: aumentar energias renováveis exceto hidroeletricidade (solar, eólica e biomassa) para no mínimo 23% da geração total.

Nota: INDC = Intended Nationally Determined Contribution.

**Fonte: Nastari, P. (2016). Workshop on Perspectives of the biomethane contribution to increase NG offer. September 14, 2016. GBIO/RCGI/USP**

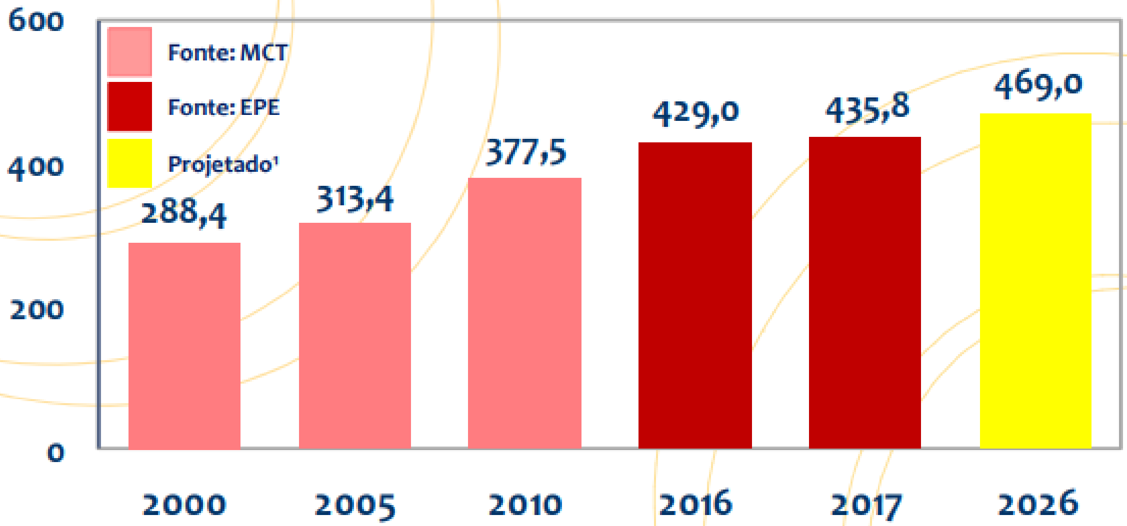
# COP-21 – Biocombustíveis

PARIS2015
CONFERÊNCIA DA ONU SOBRE MUDANÇA CLIMÁTICA
COP21·CMP11

- Aumentar a participação dos biocombustíveis na matriz energética para 18% significa:
  - Expandir a produção e o uso domestico para entre 50 e 54 bilhões de litros/ano;
  - Equivale a uma expansão, sobre base 2016, de 330 milhões de tons de cana;
  - 2030 está apenas 2 ciclos de cana à frente!

# Evolução das emissões de $CO_2$

- Evolução das emissões totais antrópicas associadas à matriz energética brasileira em $MtCO_2$-eq

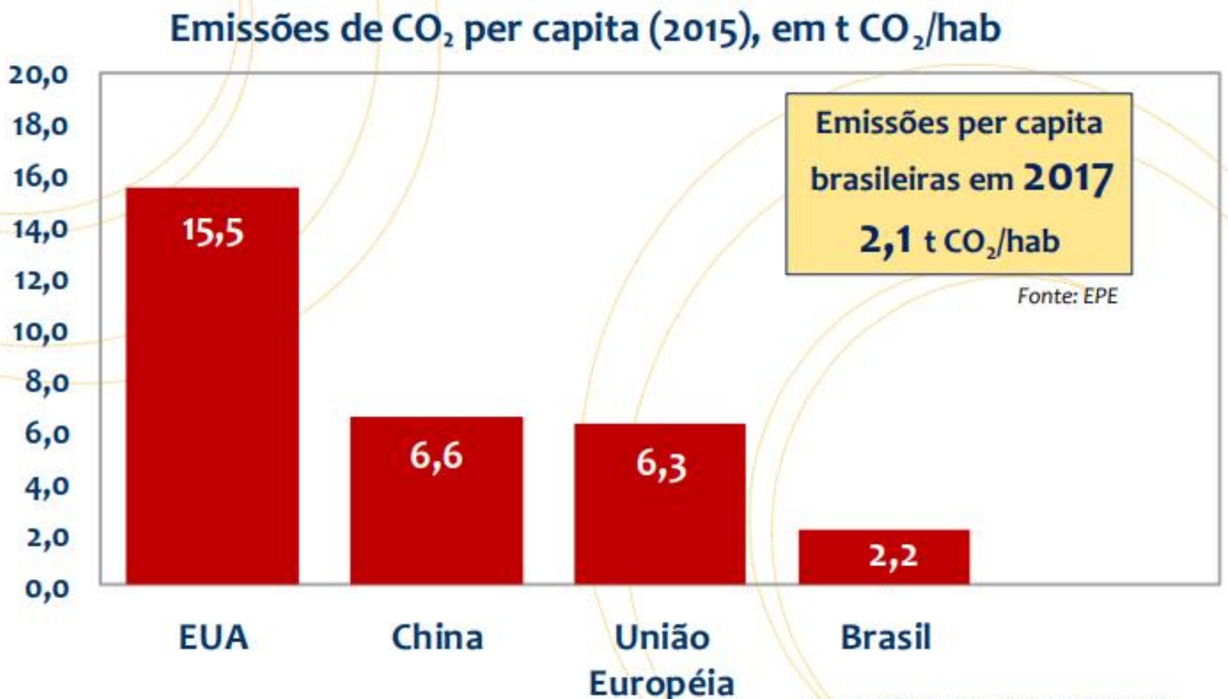



| Crescimento Emissões Totais - $MtCO_2eq$ | | |
|---|---|---|
| Indicador | Realizado | Projetado[1] |
| | 2000 a 2017 | 2000 a 2026 |
| **Taxa média de crescimento anual** | **2,5%** | **1,9%** |

[1] PDE 2026.

# Emissões de $CO_2$ per capita

- Produzindo e consumindo energia, cada brasileiro emite, em média, 7 vezes menos do que um americano e 3 vezes menos do que um europeu ou um chinês.

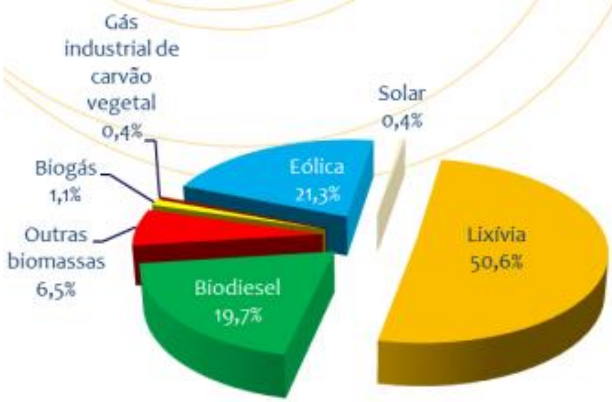



Fonte: Agência Internacional de Energia.
Elaboração: EPE

# Repartição de 'lixívia e outras renováveis'

**lixívia e outras renováveis**

**5,8%**




| Lixívia e outras renováveis (mil tep) | 2016 | 2017 | Δ 17 / 16 |
|---|---|---|---|
| Lixívia | 8.447 | 8.658 | 2,5% |
| Biodiesel | 3.009 | 3.366 | 11,8% |
| Outras biomassas[1] | 1.103 | 1.117 | 1,3% |
| Biogás | 137 | 191 | 39,5% |
| Gás industrial de carvão vegetal | 83 | 74 | -10,4% |
| Eólica | 2.880 | 3.644 | 26,5% |
| Solar | 7 | 72 | 875,6% |
| **Total** | **15.667** | **17.122** | **9,3%** |

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

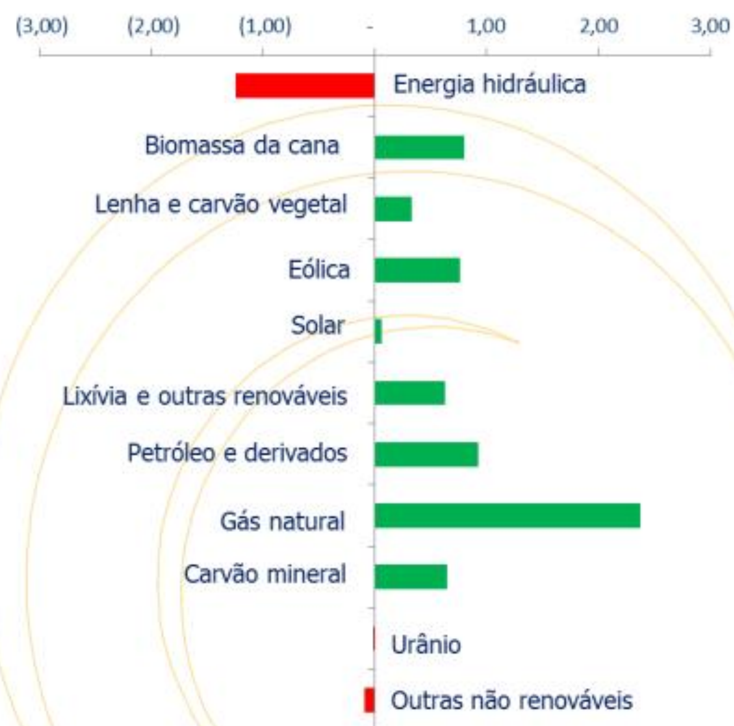
# BEN 2018

## Oferta interna de energia 2017/2016

| Fonte (Mtep) | 2016 | 2017 | Δ 17 / 16 |
|---|---|---|---|
| **RENOVÁVEIS** | **125,3** | **126,7** | **1,1%** |
| Energia hidráulica[1] | 36,3 | 35,0 | -3,4% |
| Biomassa da cana | 50,3 | 51,1 | 1,6% |
| Lenha e carvão vegetal | 23,1 | 23,4 | 1,4% |
| Eólica | 2,9 | 3,6 | 26,5% |
| Solar | 0,007 | 0,072 | 875,6% |
| Lixívia e outras renováveis | 12,8 | 13,4 | 4,9% |
| **NÃO RENOVÁVEIS** | **163,0** | **166,8** | **2,4%** |
| Petróleo e derivados | 105,4 | 106,3 | 0,9% |
| Gás natural | 35,6 | 37,9 | 6,7% |
| Carvão mineral | 15,9 | 16,6 | 4,1% |
| Urânio ($U_3O_8$) | 4,2 | 4,2 | -0,4% |
| Outras não renováveis | 1,9 | 1,8 | -4,7% |

[1] *Inclui importação de eletricidade oriunda de fonte hidráulica*

*variação Mtep 2017/2016*

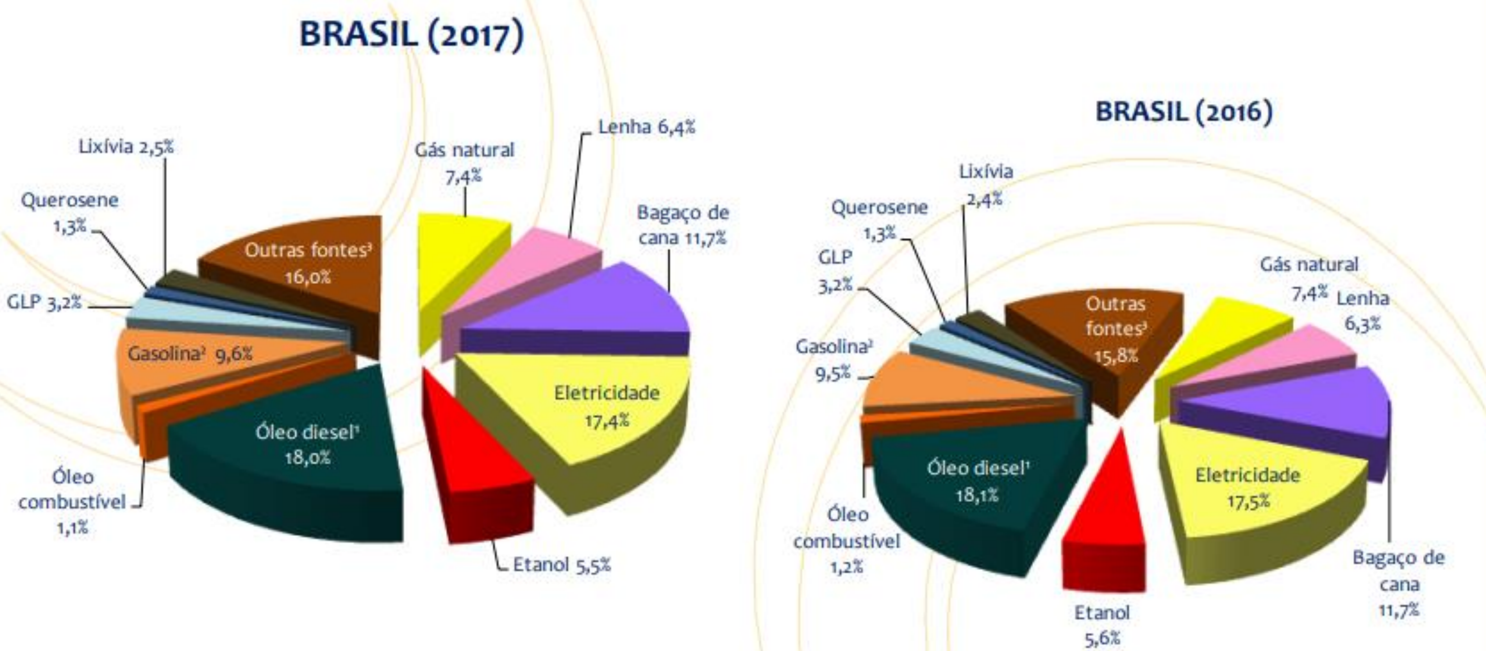



epe

# BEN (2020) – Ano Base 2019
# BALANCO ENERGETICO NACIONAL

- Exercício
- Comparação das emissões entre  Brasil e o mundo

# Consumo final de energia por fonte




[1] *Inclui biodiesel*

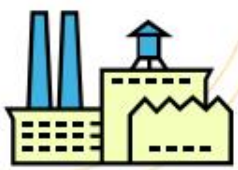
[2] *Inclui gasolina de aviação*

[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.*

epe
Empresa de Pesquisa Energética

# Quem usou a energia no Brasil

**indústrias**
**33,3%**



**transportes**
**32,5%**

**residências**
**9,6%**

**setor energético**
**10,0%**

| | |
|---|---|
| **2017** | **260,0 Mtep** |
| **2016** | **255,5 Mtep** |
| ↑ | **1,7%** |

**agropecuária**
**4,0%**

**serviços**
**4,8%**

**uso não energético**
**5,8%**

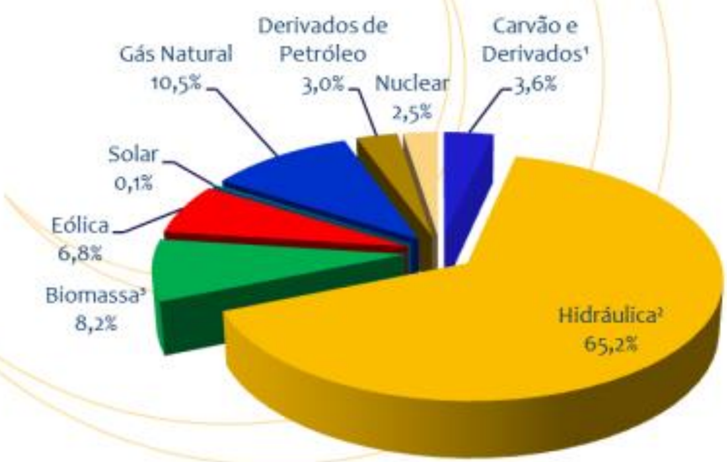

**Produção industrial e transporte de carga / passageiros** respondem por aproximadamente **66%** do consumo de energia do país.

IEE USP

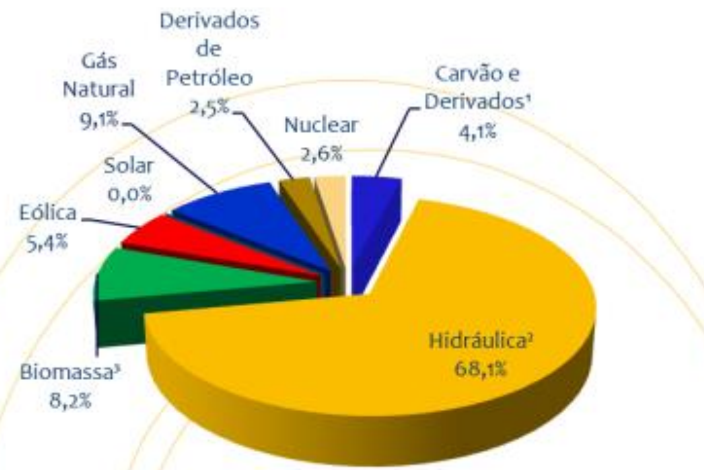
GRUPO DE PESQUISA EM BIOENERGIA
Universidade de São Paulo | Instituto de Energia e Ambiente

# Matriz Elétrica Brasileira

## BRASIL (2017)




## BRASIL (2016)




oferta hidráulica² em 2017: **407,3 TWh**

oferta hidráulica² em 2016: **421,7 TWh**

oferta **total**² em 2017: **624,3TWh**

oferta **total**² em 2016: **619,7 TWh**

*¹ Inclui gás de coqueria, gás de alto forno, gás de aciaria e alcatrão*

*² Inclui importação*

*³ Inclui lenha, bagaço de cana, lixívia e outras fontes primárias.*

epe Empresa de Pesquisa Energética

# Capacidade Instalada[1] (MW)

| Fonte | 2016 | 2017 | Δ 17/16 |
|---|---|---|---|
| Hidrelétrica | 96.925 | 100.275 | 3,5% |
| Térmica[2] | 41.275 | 41.628 | 0,9% |
| Nuclear | 1.990 | 1.990 | 0,0% |
| Eólica | 10.124 | 12.283 | 21,3% |
| Solar | 24 | 935 | 3836% |
| Capacidade disponível | 150.338 | 157.112 | 4,5% |

[1] *Não inclui micro e minigeração distribuídas*
[2] *Inclui biomassa, gás, petróleo e carvão mineral*

IEE USP

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

| Setores | 1970 | 1975 | 1980 | 1985 | 1990 | 1995 | 2000 | 2005 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Energia | 114 | 172 | 212 | 201 | 221 | 241 | 297 | 312 | 367 | 380 | 416 | 449 |
| Agropecuária | 161 | 206 | 240 | 256 | 287 | 317 | 328 | 392 | 406 | 418 | 413 | 418 |
| Processos industriais | 14 | 22 | 39 | 46 | 51 | 65 | 76 | 83 | 95 | 101 | 101 | 99 |
| Resíduos | 16 | 19 | 22 | 25 | 29 | 33 | 38 | 41 | 49 | 48 | 48 | 49 |
| Mudança de uso da terra | n.d | n.d | n.d | n.d | 1.247 | 2.204 | 1.458 | 1.506 | 599 | 568 | 466 | 542 |
| Total * | 305* | 418* | 512* | 529* | 1.835 | 2.860 | 2.197 | 2.335 | 1.515 | 1.515 | 1.443 | 1.558 |
| Remoções (florestas em áreas protegidas) | – | – | – | – | -304 | -305 | -327 | -374 | -409 | -409 | -409 | -411 |
| Emissões líquidas * | 305 | 418 | 512 | 529 | 1.531 | 2.555 | 1.870 | 1.961 | 1.106 | 1.106 | 1.034 | 1.147 |

*n.d.: não foram estimadas as emissões de mudança de uso da terra para o período de 1970 a 1989.

Tabela 1: evolução das emissões brutas e líquidas de GEE no Brasil por setor entre 1970 e 2013 (Mt $CO_2e$)

Termoelétricas emergenciais

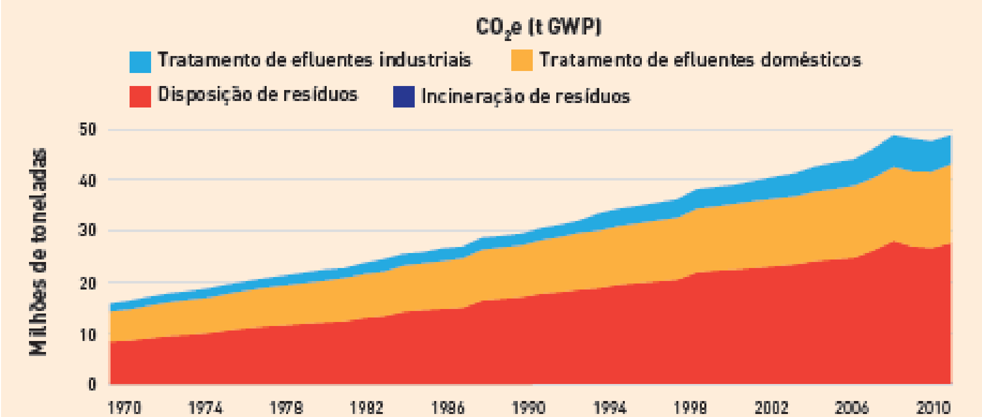
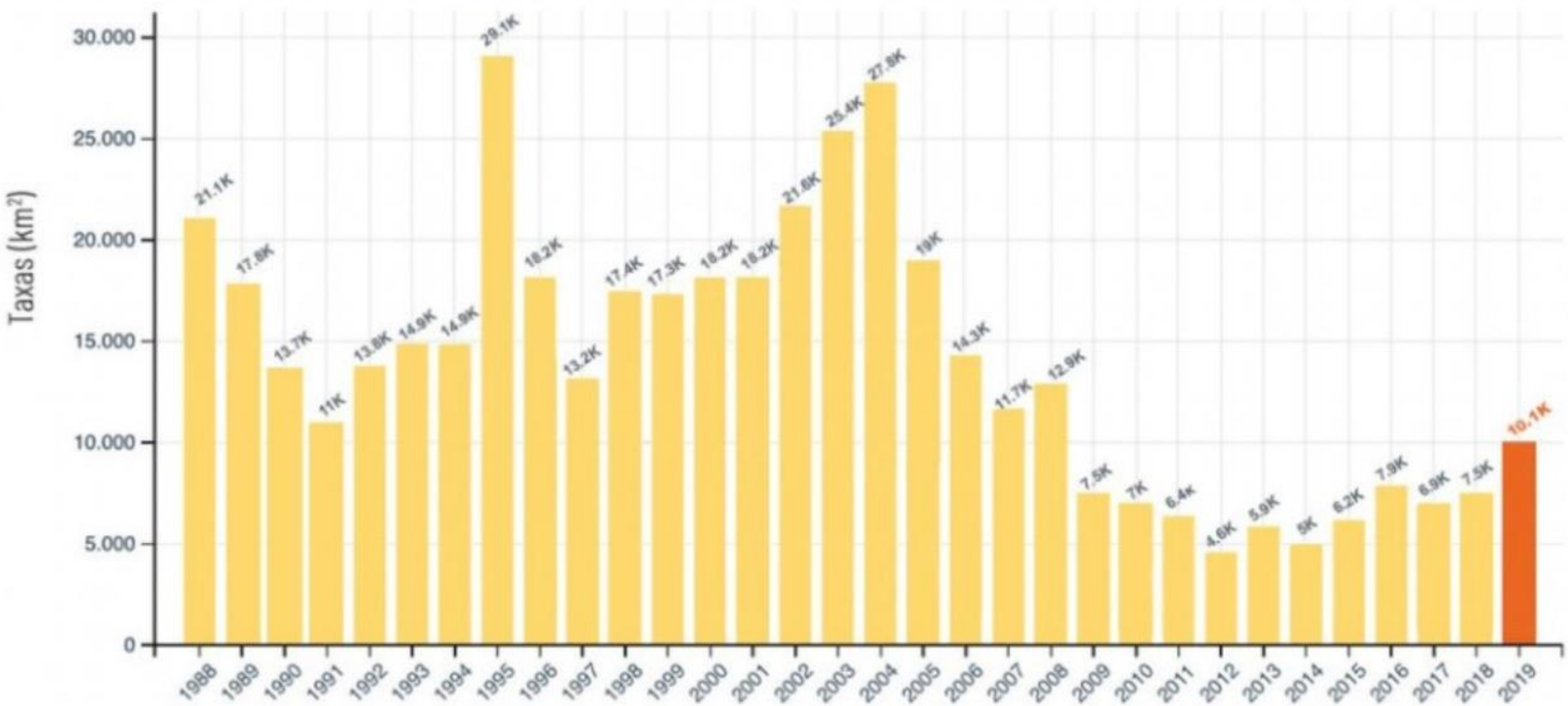



Figura 11: emissões por tratamento de resíduos (1970-2013)

**Emissões de carbono no Brasil: Aumento nas emissões do setor de energia e no setor de resíduos**

Fonte: Observatorio do Clima
https://s3-sa-east-1.amazonaws.com/seeg.tracersoft.com.br/wp-content/uploads/2015/08/sintese_2015.pdf

# Taxas oficiais de desmatamento na Amazônia, calculadas pelo PRODES

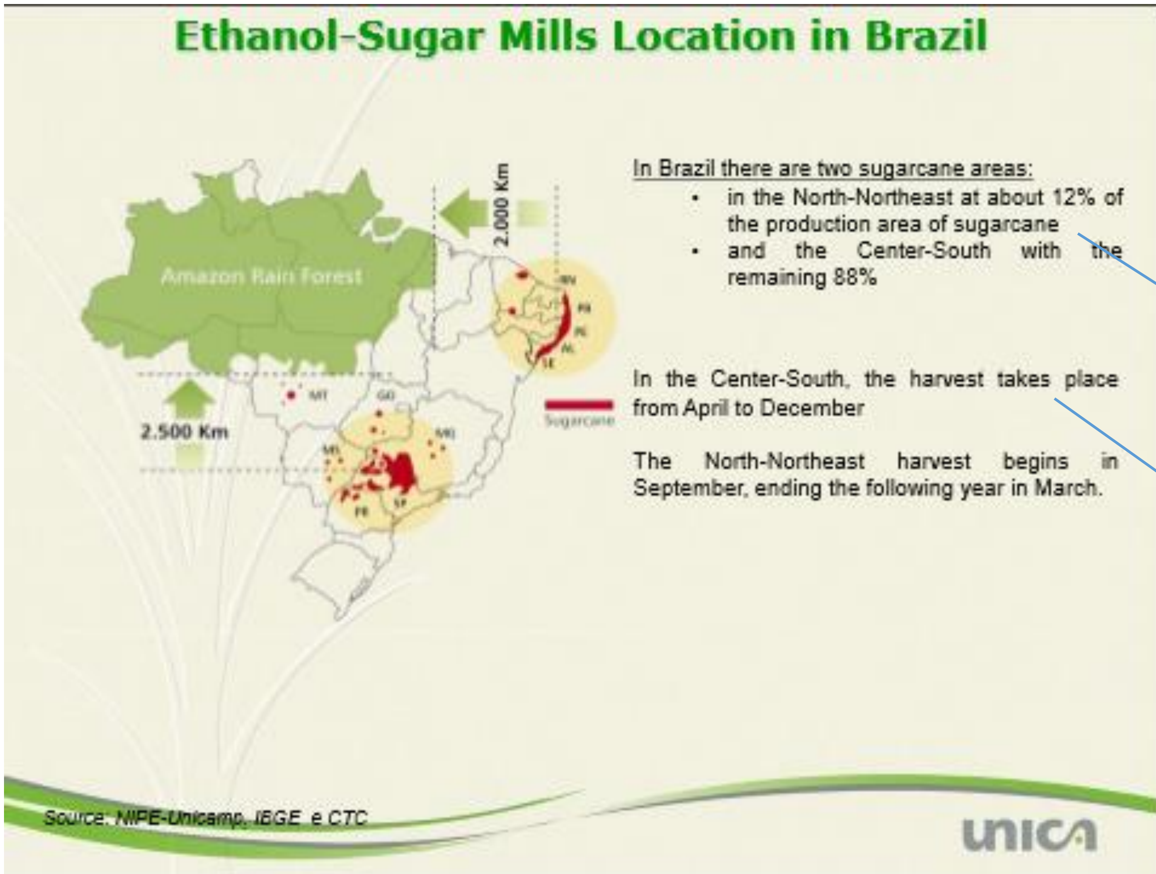


# Biocombustíveis no Brasil

# PRODUÇÃO DE ETANOL

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

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



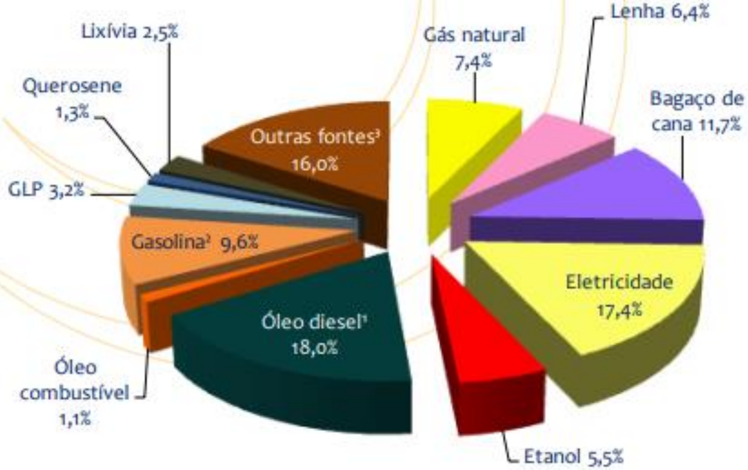

**2016/17 season**

**N-Northeast :**
**44,7 MM t cane**

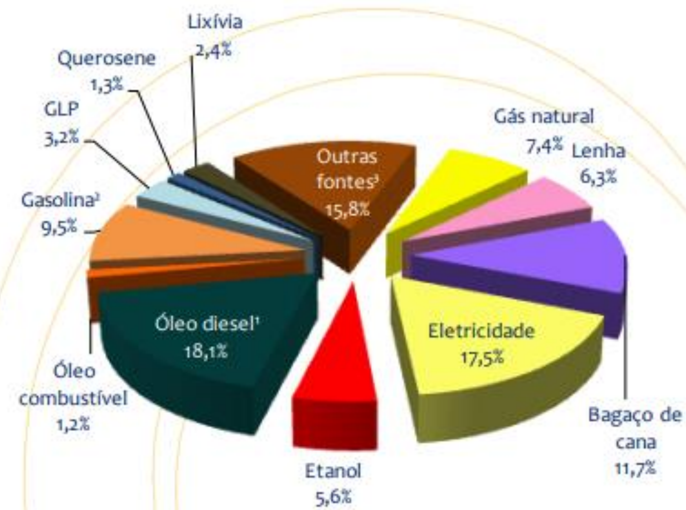
**Center-South:**
**607,1 MM t cane**
**No irrigation**
**Ferti-irrigation w/ vinasse**

# Consumo final de energia por fonte

## BRASIL (2017)




## BRASIL (2016)



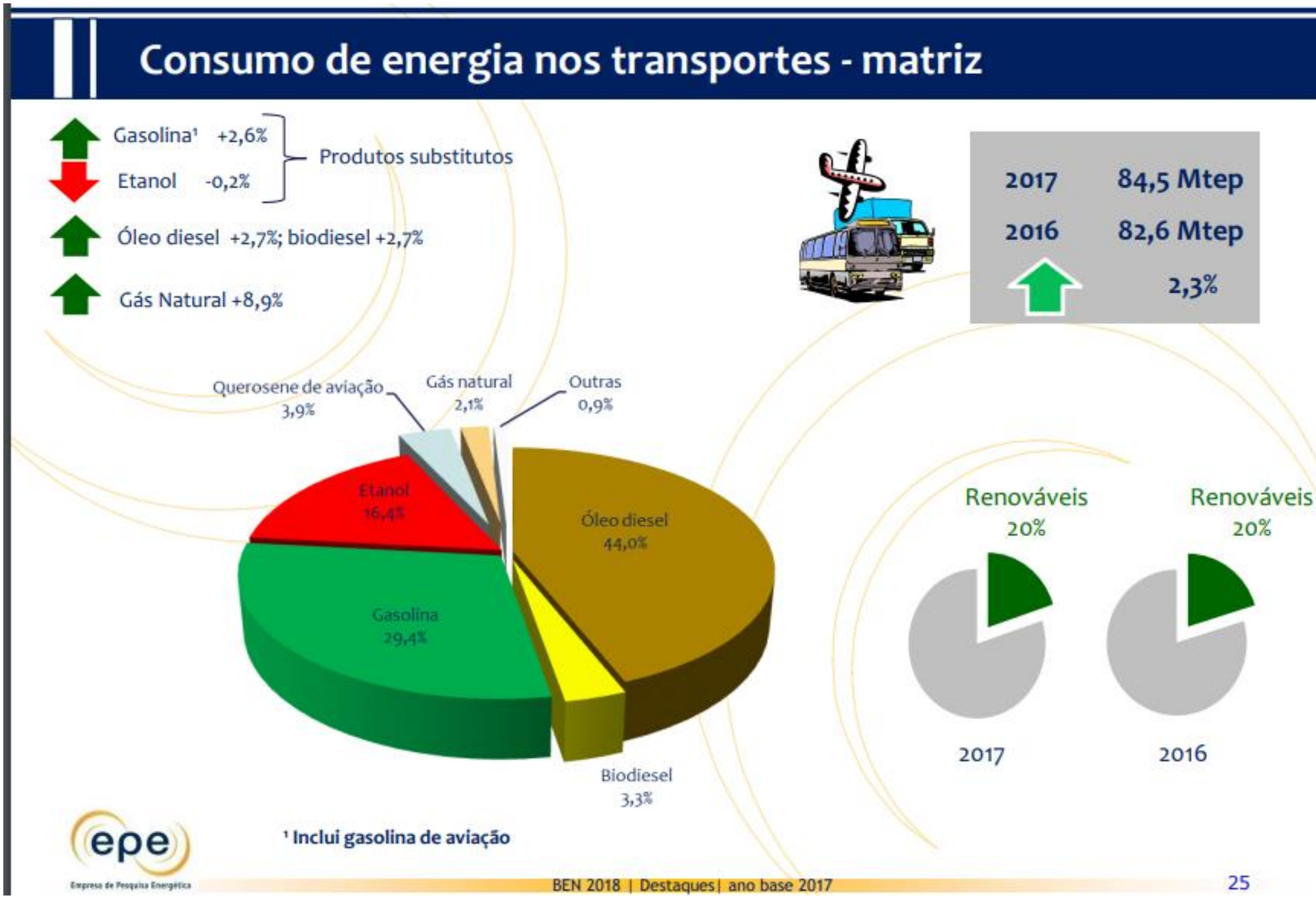

¹ *Inclui biodiesel*

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.*

epe

Empresa de Pesquisa Energética

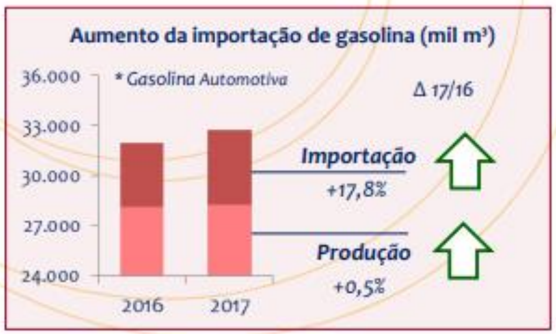


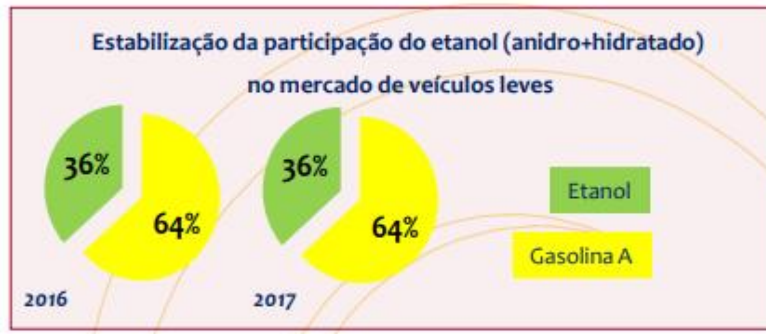
Consumo de energia nos transportes - matriz
Gasolina¹ +2,6%
Etanol -0,2%
Produtos substitutos
Óleo diesel +2,7%; biodiesel +2,7%
Gás Natural +8,9%
2017 84,5 Mtep
2016 82,6 Mtep
2,3%
Querosene de aviação 3,9%
Gás natural 2,1%
Outras 0,9%
Etanol 16,4%
Óleo diesel 44,0%
Gasolina 29,4%
Biodiesel 3,3%
Renováveis 20%
Renováveis 20%
2017
2016
¹ Inclui gasolina de aviação
epe
Empresa de Pesquisa Energética
BEN 2018 | Destaques| ano base 2017
25

# Consumo de energia nos transportes - destaques

Etanol hidratado -6,9%

Gasolina automotiva 2,6%





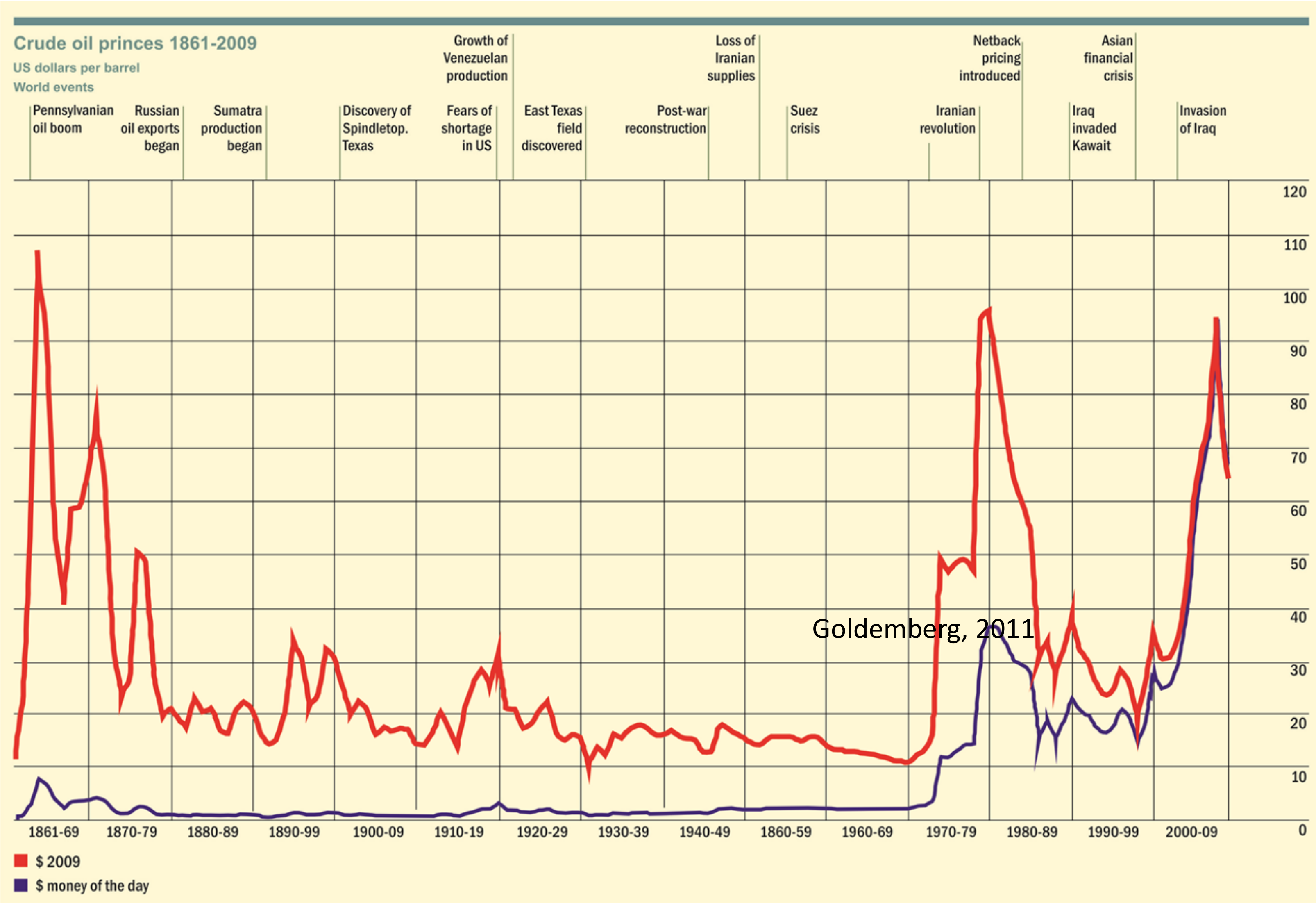
Fonte: EPE; IBGE. Elaboração: EPE

# 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

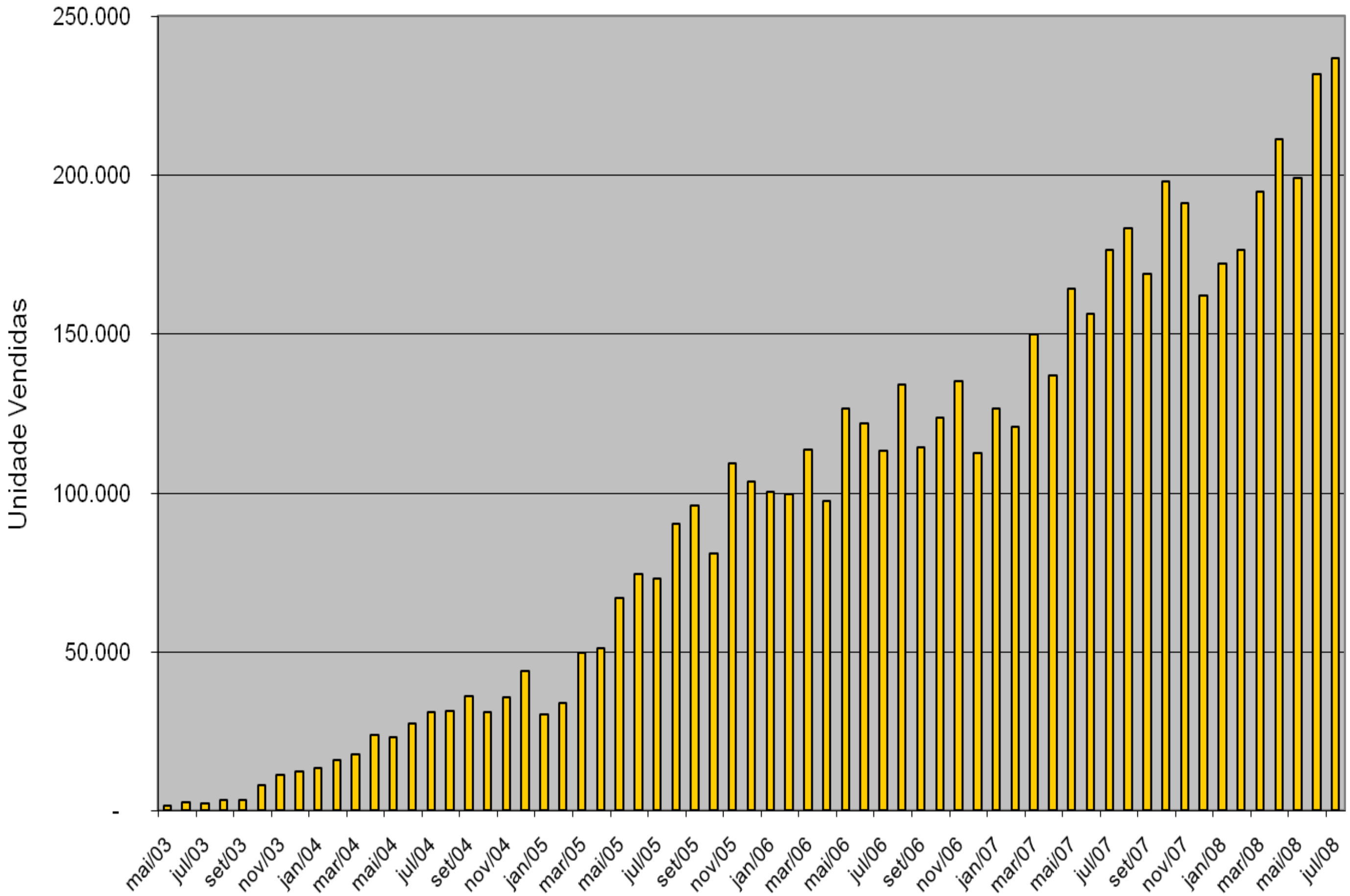
  toda gasolina: 20 a 27% de etanol (em volume) – gasohol
- Atualmente – economicamente competitivo com a gasolina ?

# Evolucao historica dos precos do petroleo



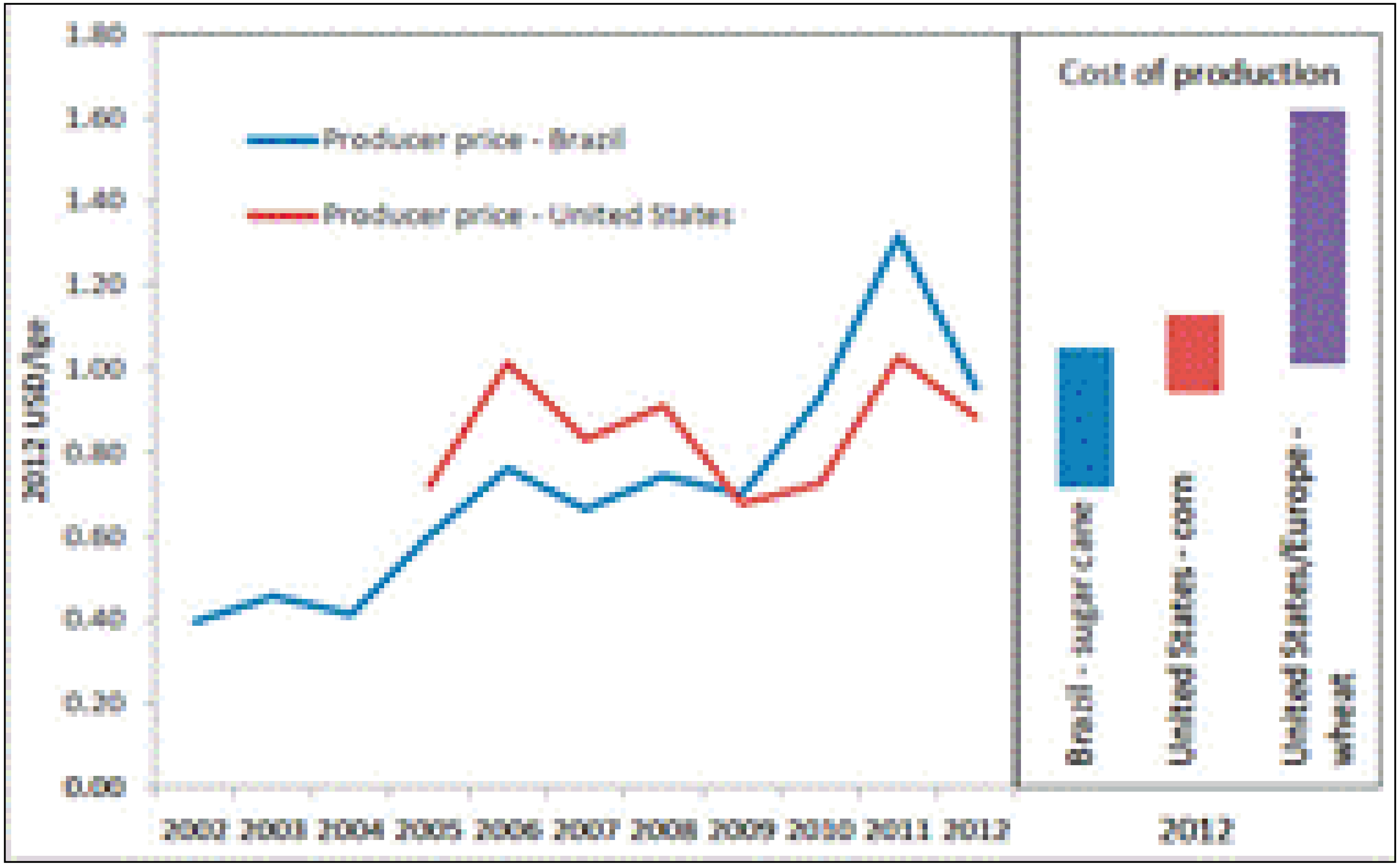

**Source: Datagro, Icone e UNICA**

# Vendas de Veículos Bicombustíveis (flex)

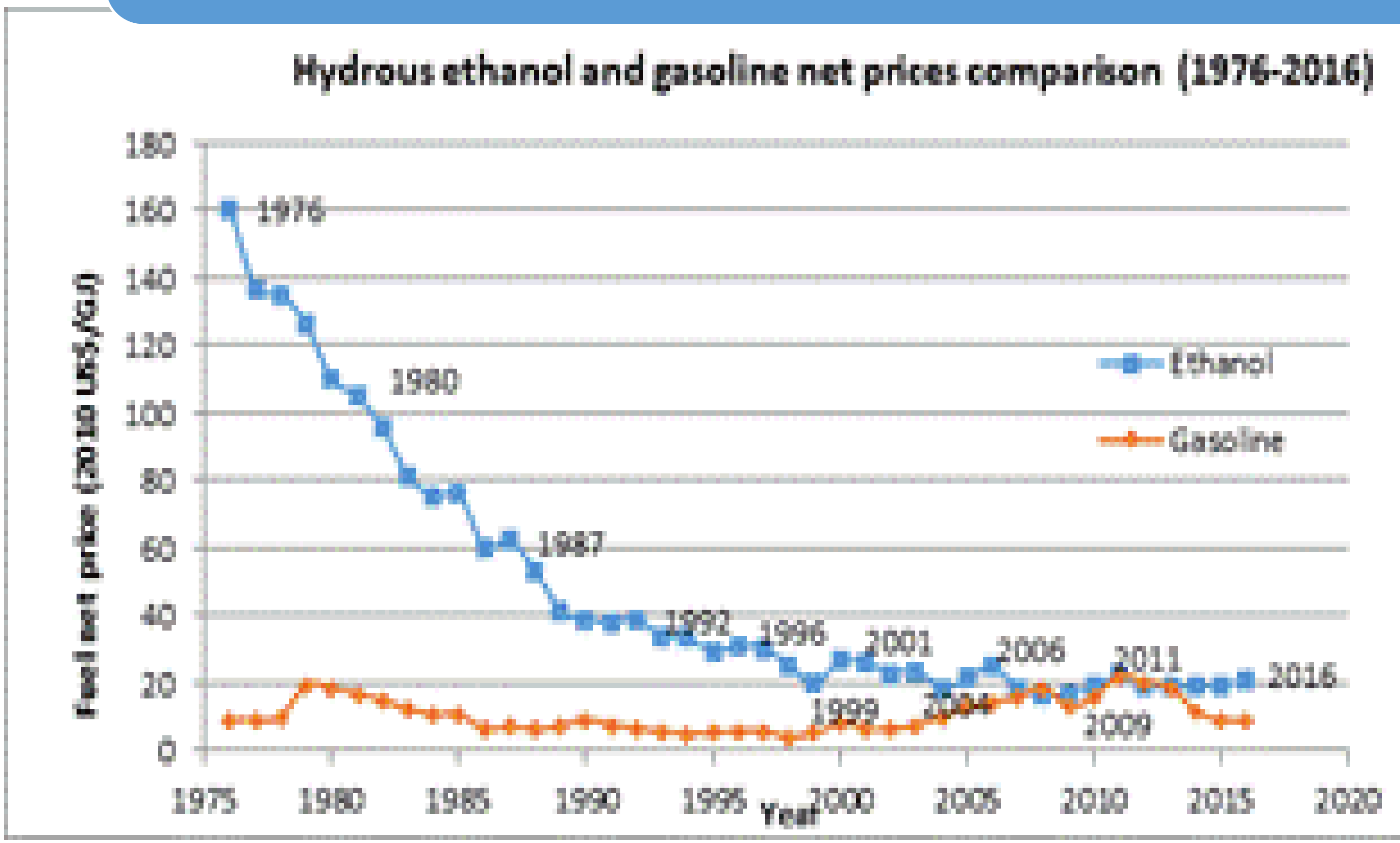



**Fonte: ANFAVEA**

# Ethanol production costs for different crops IRENA(2013)

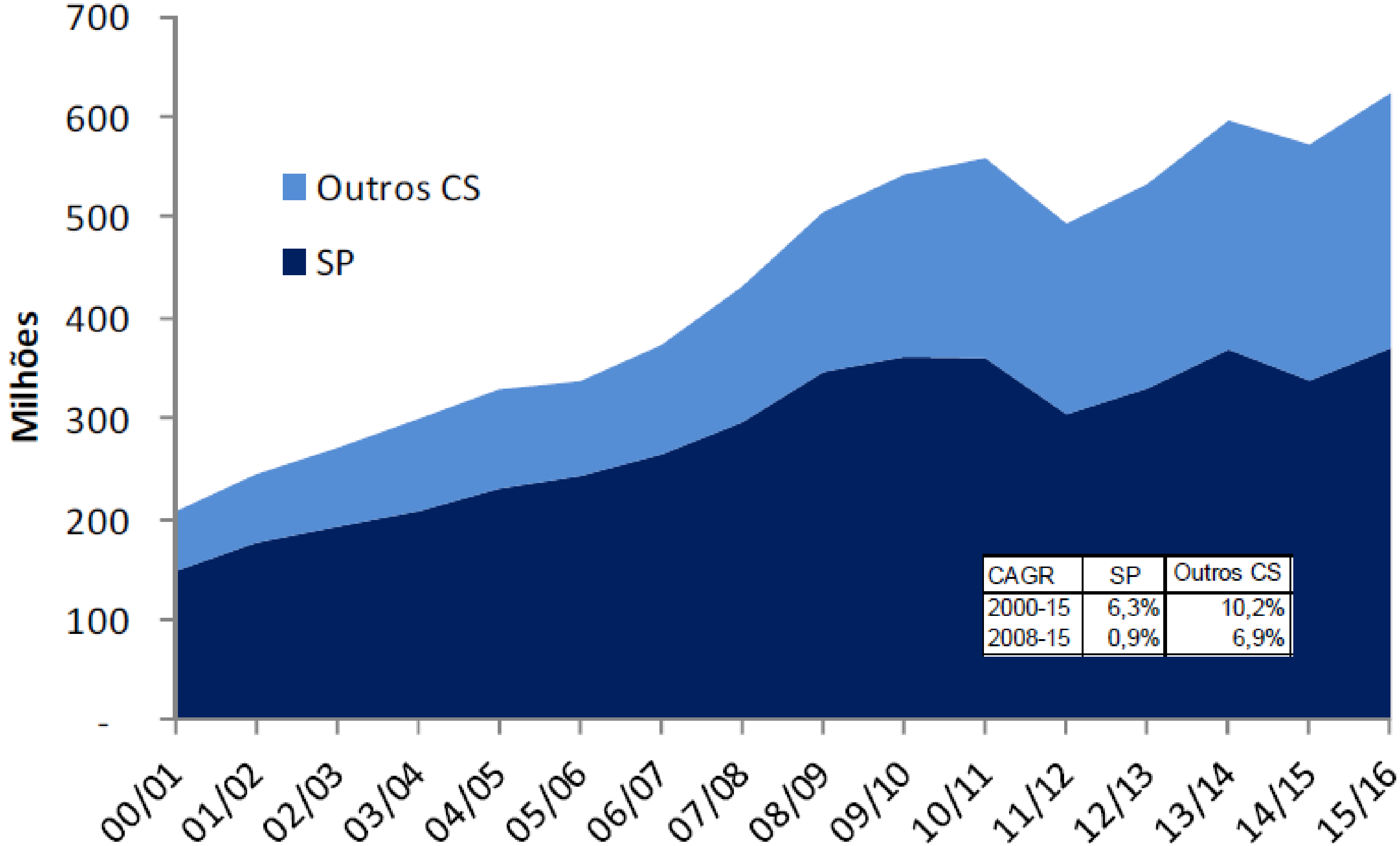


# *Brazil - Hydrous (sugarcane) ethanol and gasoline (net) prices comparison (1976-2016)*



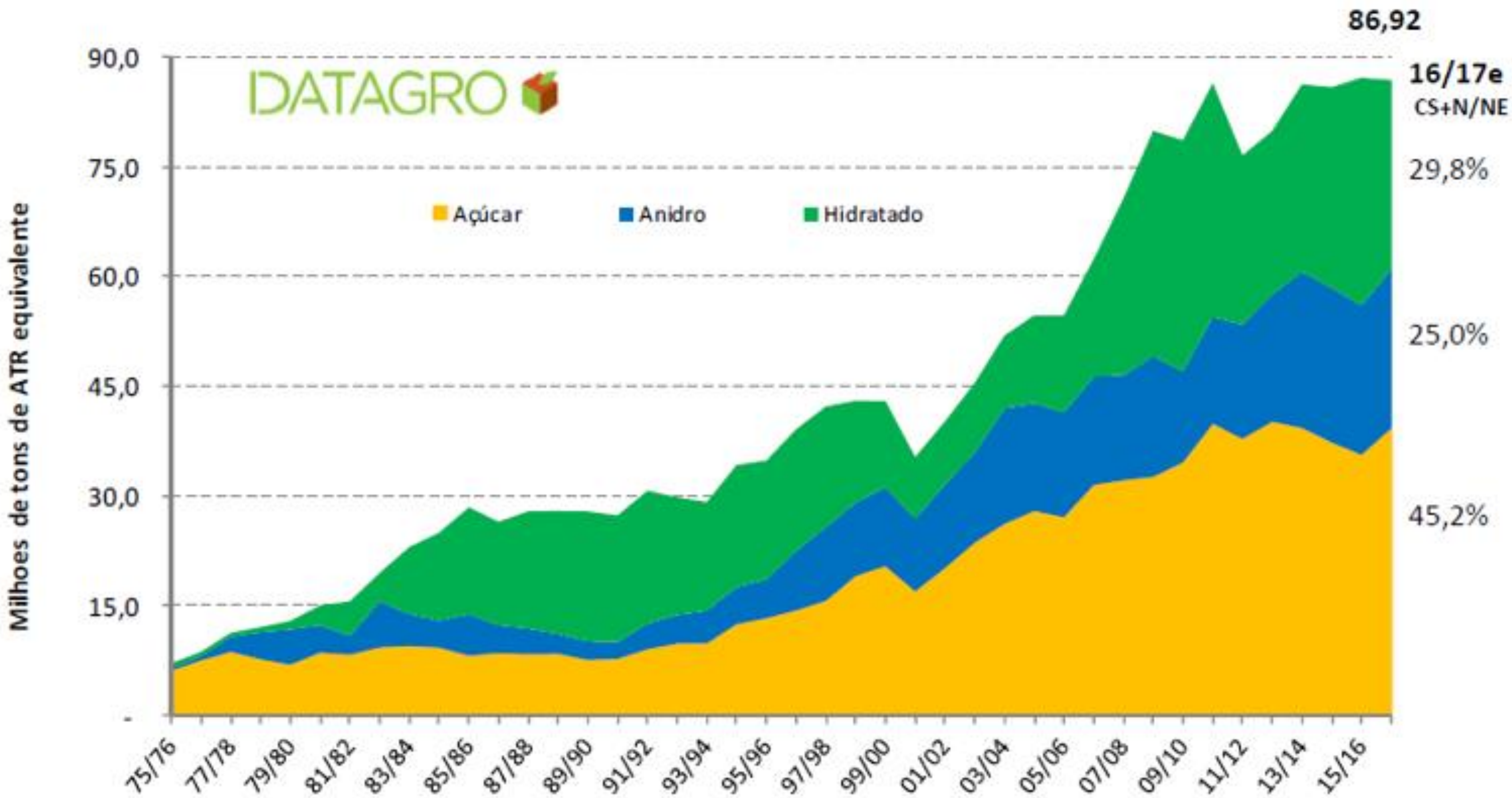

Source: J Goldemberg, P Guardabassi (IEE/USP). Personal Communication (2017)

# Moagem de Cana em SP e CS




| CAGR | SP | Outros CS |
|---|---|---|
| 2000-15 | 6,3% | 10,2% |
| 2008-15 | 0,9% | 6,9% |

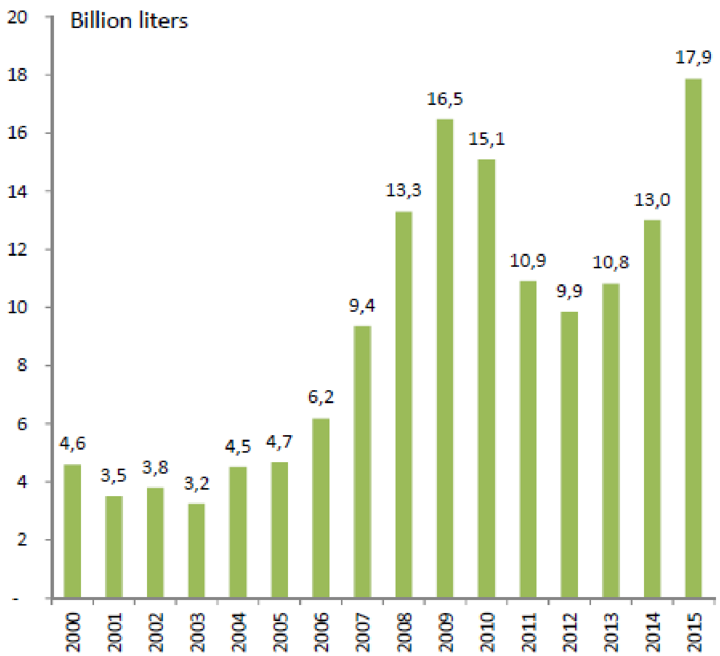
Fonte: DATAGRO



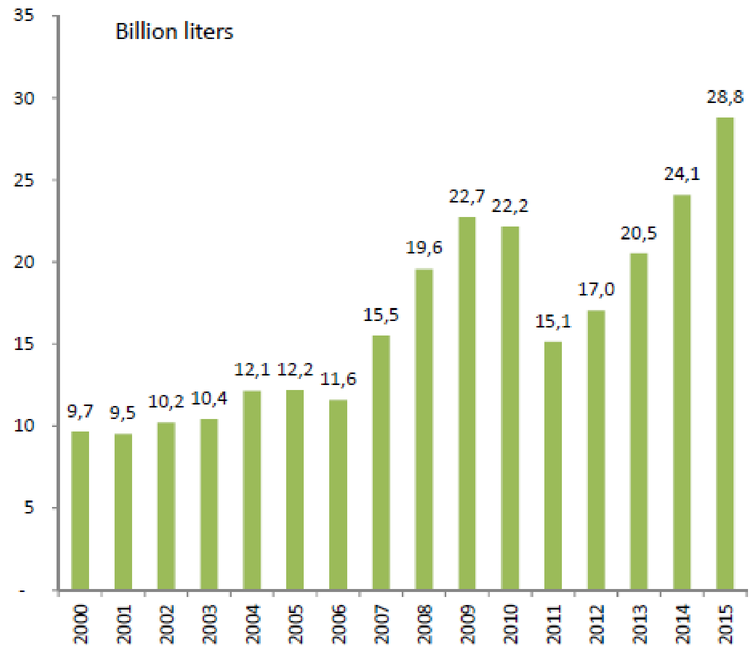

Fonte: DATAGRO

# Consumo de Etanol Combustível no Brasil

**Consumo de Etanol Hidratado Combustivel**




**Consumo de Etanol Total Comb. (Hidr+Anidro)**




Fonte: Calculado pela DATAGRO a partir de dados da ANP

# Impostos incidentes nos veículos

| Tipo de Veículo | IPI* |
|---|---|
| Veículos a gasolina | 13% - 25% |
| Veículos a álcool (hidratado) | 11% - 18% |
| Veículos bicombustível | 11% - 18% |

*A alíquota varia de acordo com a potência dos veículos

# Impostos incidentes nos combustíveis

| Combustível | ICMS* |
|---|---|
| Gasolina | 20% - 31% |
| Álcool hidratado | 12% - 31% |
| Álcool anidro (misturado à gasolina) | 0% |

*A alíquota é variável em cada Estado da Federação

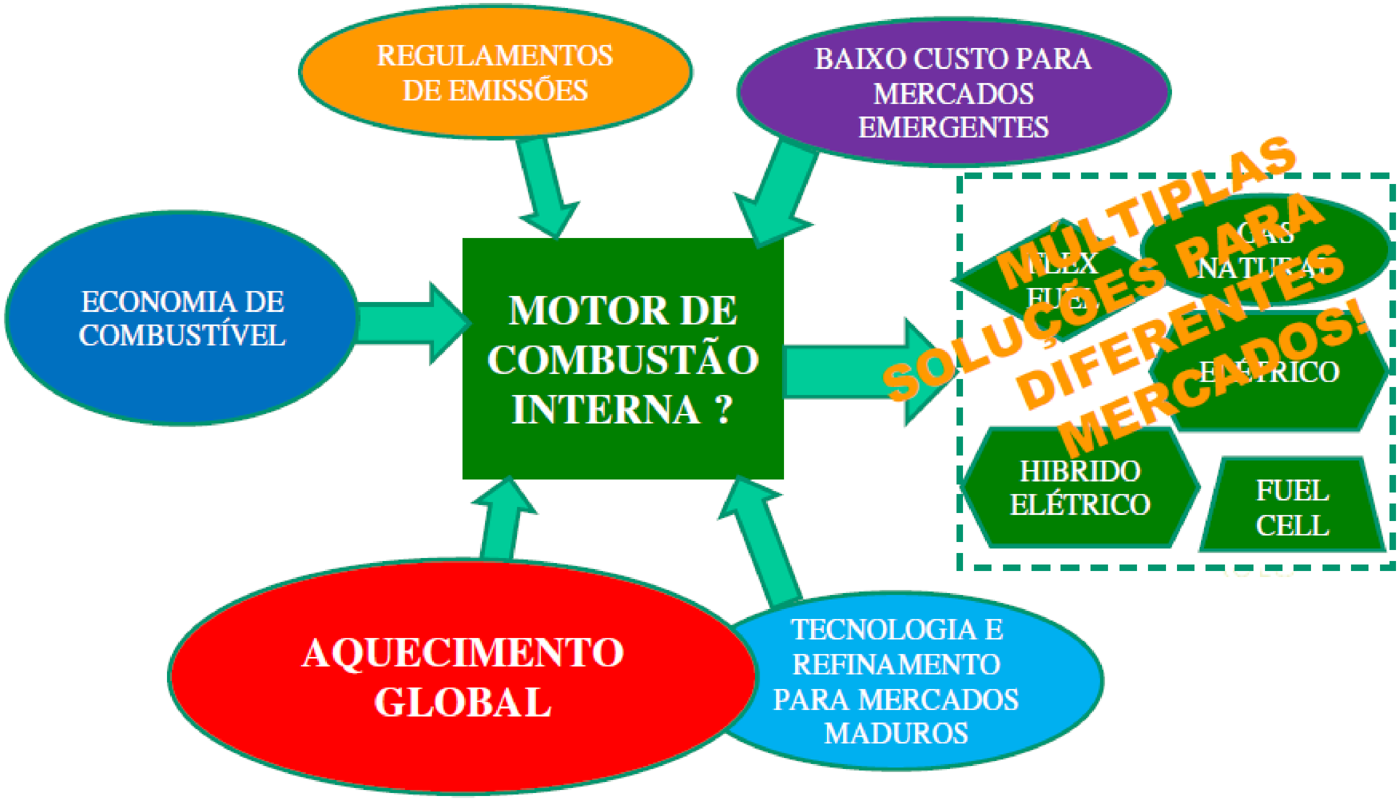
## Impostos incidentes nos combustíveis

| Combustível | CIDE (2020) |
|---|---|
| Gasolina | R$ 0,10/litro |
| Óleo diesel | 0 |
| Etanol | 0 |
| Gás natural | 0 |

http://receita.economia.gov.br/orientacao/tributaria/declaracoes-e-demonstrativos/ecf-escrituracao-contabil-fiscal/perguntas-e-respostas-pessoa-juridica-2020-arquivos/capitulo-xxvi-cide-combustiveis-2020.pdf/view

# VISÃO DE FUTURO

## EVOLUÇÃO DOS VEÍCULOS




Fonte: Nigro, F. Curso de Especialização em Energia e Meio Ambiente, IEE/USP

IEE USP

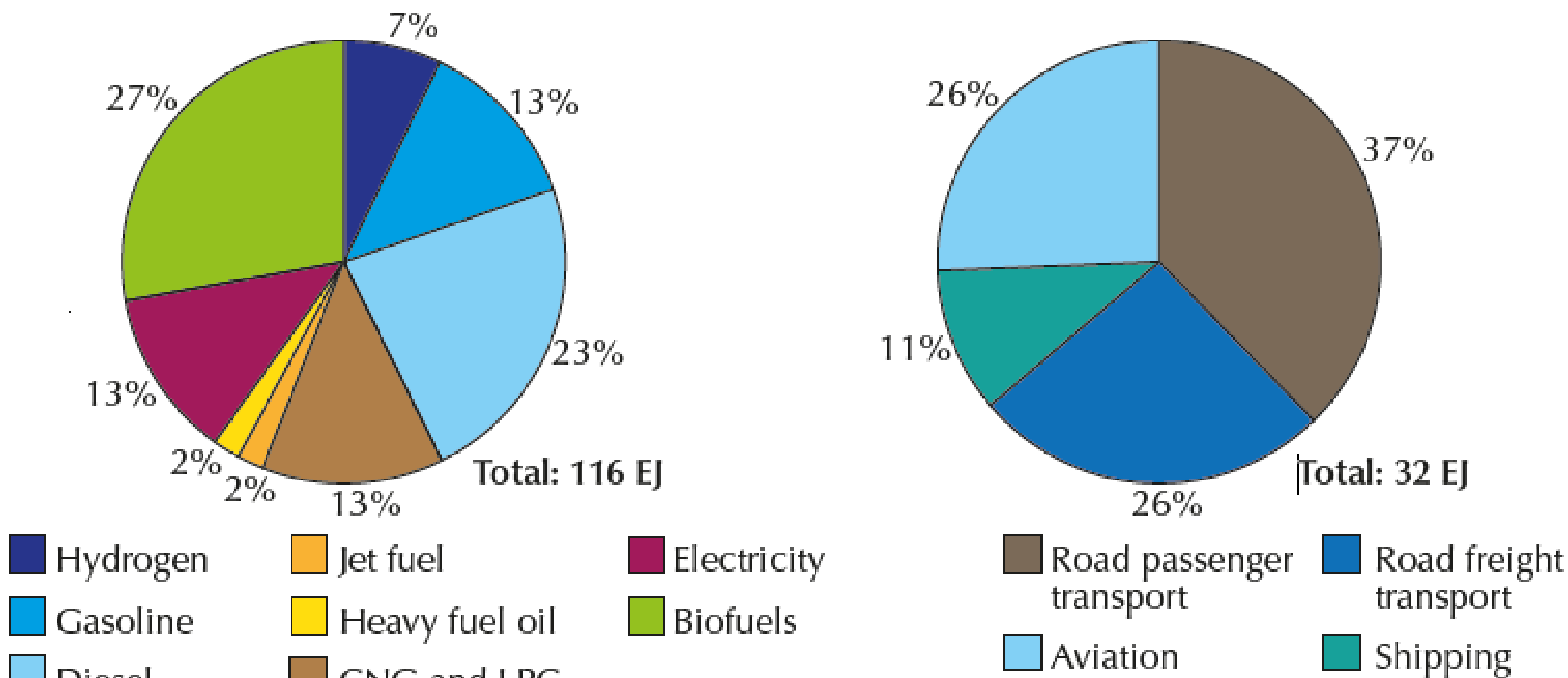
GRUPO DE PESQUISA EM BIOENERGIA
Universidade de São Paulo | Instituto de Energia e Ambiente

Stakeholders:

EDITOR
Luís Augusto Barbosa Cortez

# ROADMAP FOR SUSTAINABLE AVIATION BIOFUELS FOR BRAZIL

A Flightpath to Aviation Biofuels in Brazil




Note: CNG = compressed natural gas; LPG = liquified petroleum gas

**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.**

**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 Amsterdan - 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 | Jatropoha, 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 | |

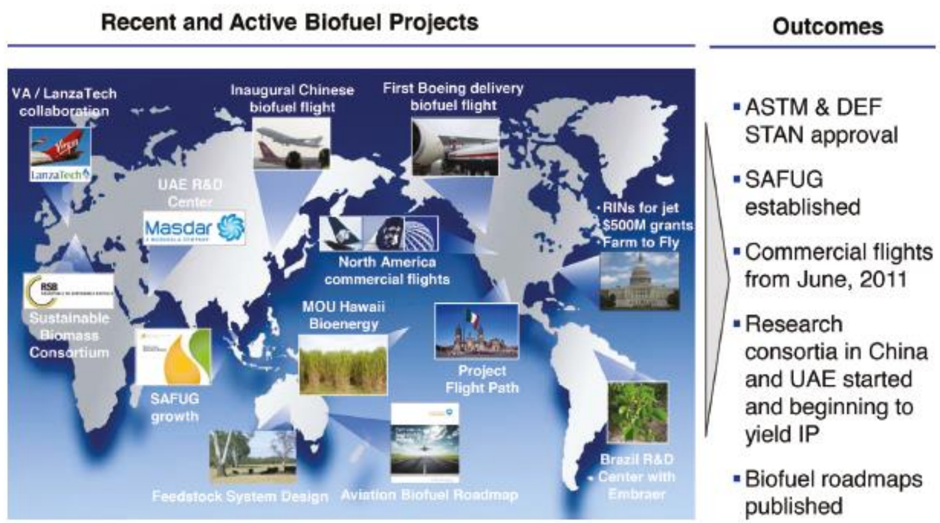



**Figure 23 Boeing global biofuel engagements. Source: Boeing apud Lyons, 2012.**

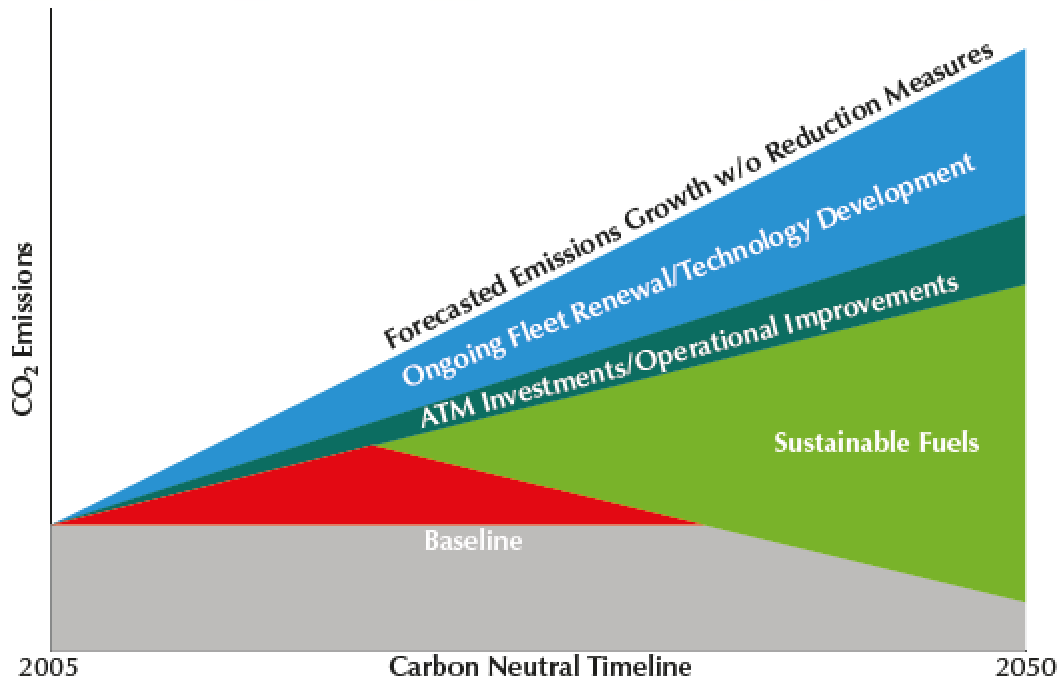



**Figure 19 Aviation actions to reduce $CO_2$. Source: Boeing apud Lyons, 2012.**

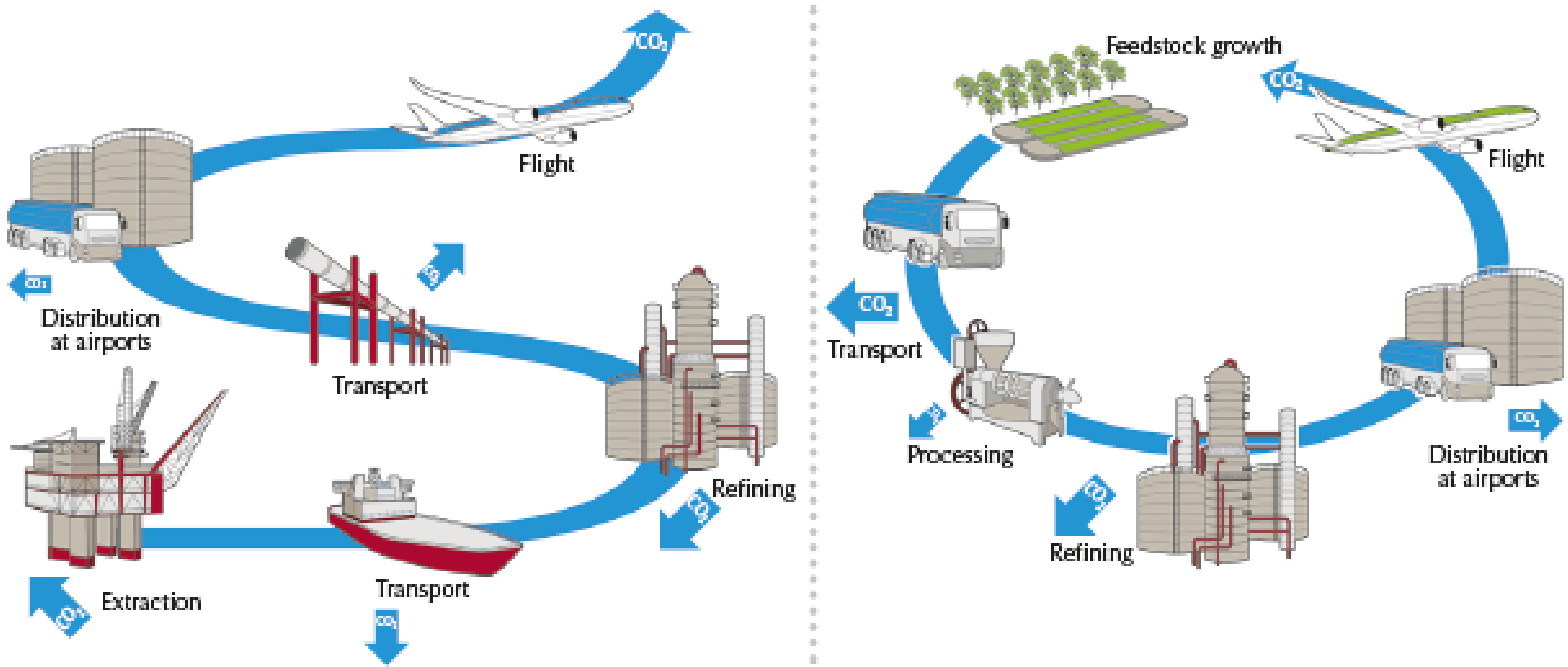



**Figure 11 Comparative Life Cycle Analysis (LCA) for $CO_2$ emissions using kerosene (left) and biofuels (right). Source: ATAG, 2011.**

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

**Incentivar a produção eficiente de biocombustíveis (base em ACV)**

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

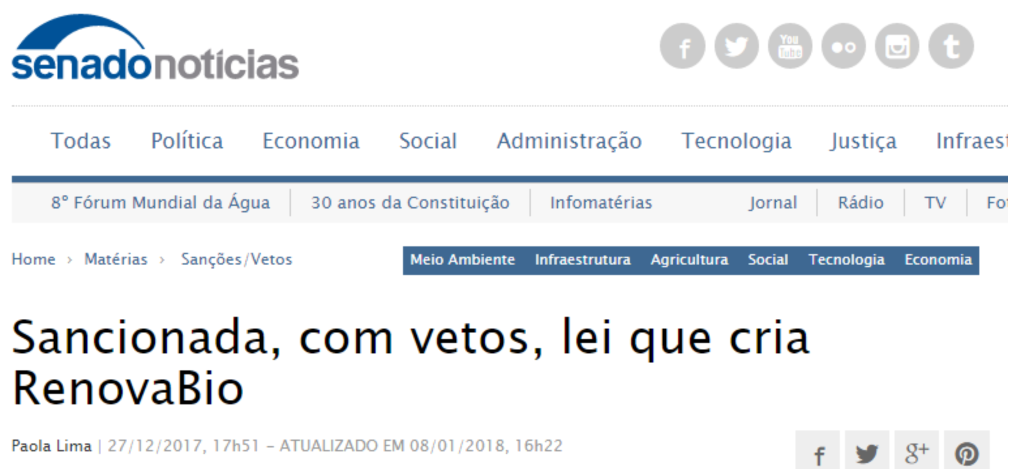
INFRAESTRUTURA

# RenovaBio vai expandir produção de biocombustível no País

Energia

Programa também vai ajudar no pı
emissões de gases de efeito estufa

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



senadonotícias

Todas | Política | Economia | Social | Administração | Tecnologia | Justiça | Infraes

8° Fórum Mundial da Água | 30 anos da Constituição | Infomatérias | Jornal | Rádio | TV | Fo

Home › Matérias › Sanções/Vetos

Meio Ambiente | Infraestrutura | Agricultura | Social | Tecnologia | Economia

# Sancionada, com vetos, lei que cria RenovaBio

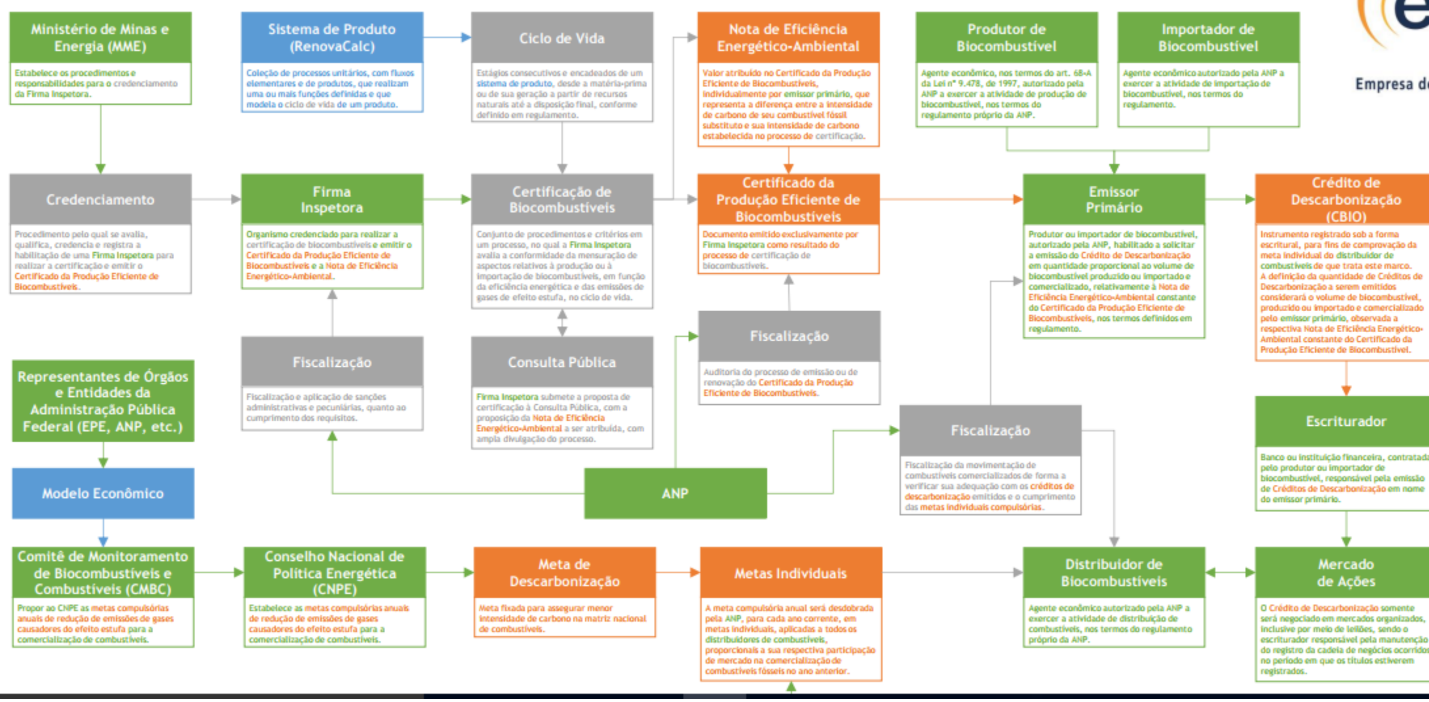
Paola Lima | 27/12/2017, 17h51 – ATUALIZADO EM 08/01/2018, 16h22

https://www12.senado.leg.br/noticias/materias/2017/12/27/sancionada-com-vetos-lei-que-cria-renovabio

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

# Fluxograma RenovaBio

Empresa de Pesquisa Energética




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

# Pesquisa

- Renovacalc – metodologia para calculo dos CBIO´s
- ANP – Lista das distribuidoras e dos CBIO´s de cada uma (redução media 10,1%)
- Atualizar – como ficaram as metas após a redução do MME?

# *Bioenergy Sustainability*

# BIOENERGY CONTRIBUTING TO ACHIEVE SUSTAINABLE DEVELOPMENT GOALS

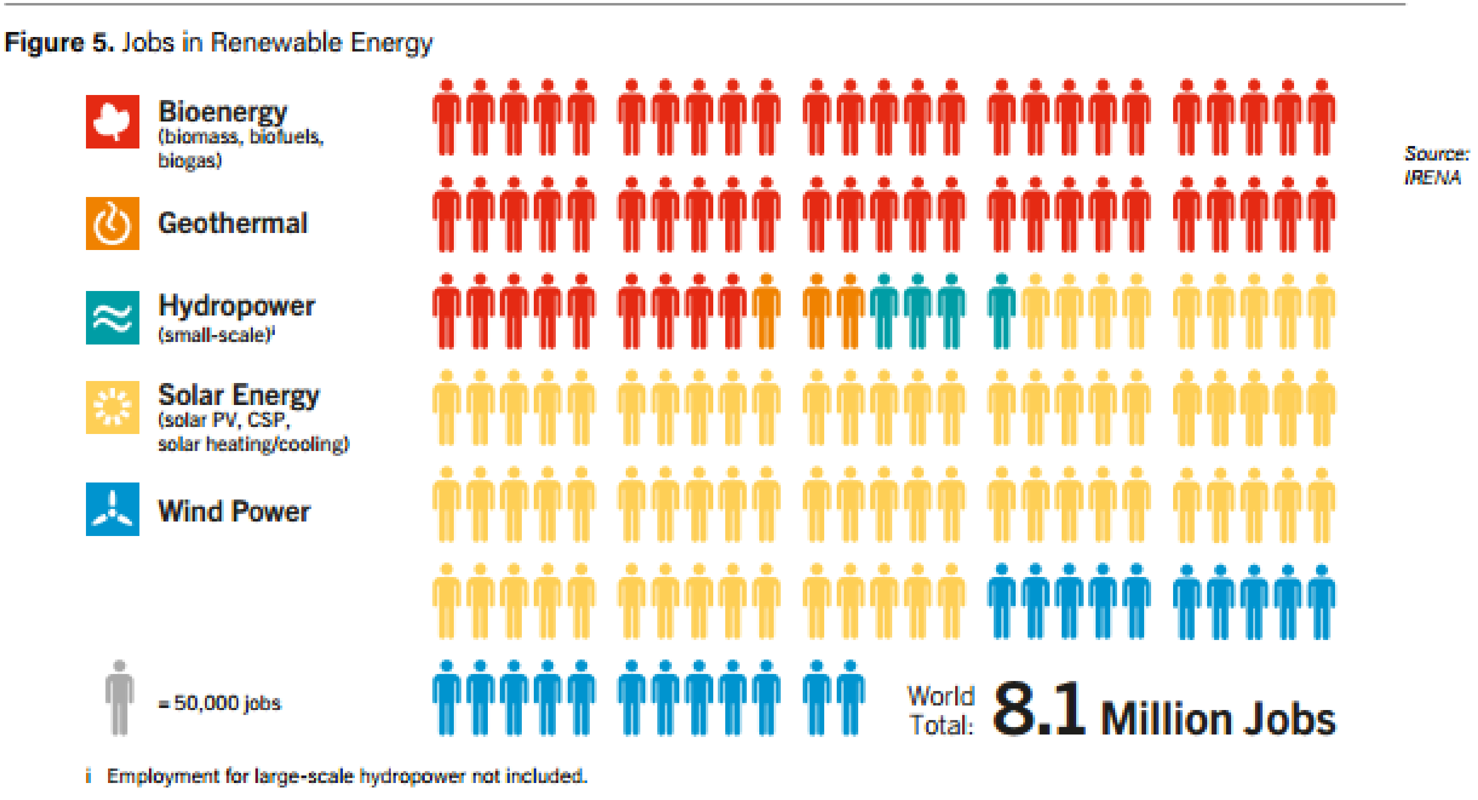

- Established in 2015 at the United Nations
- Each goal has specific targets to be achieved over the next 15 years (2030)

# *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

# Bioenergy and Jobs Creation




REN21, 2018

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

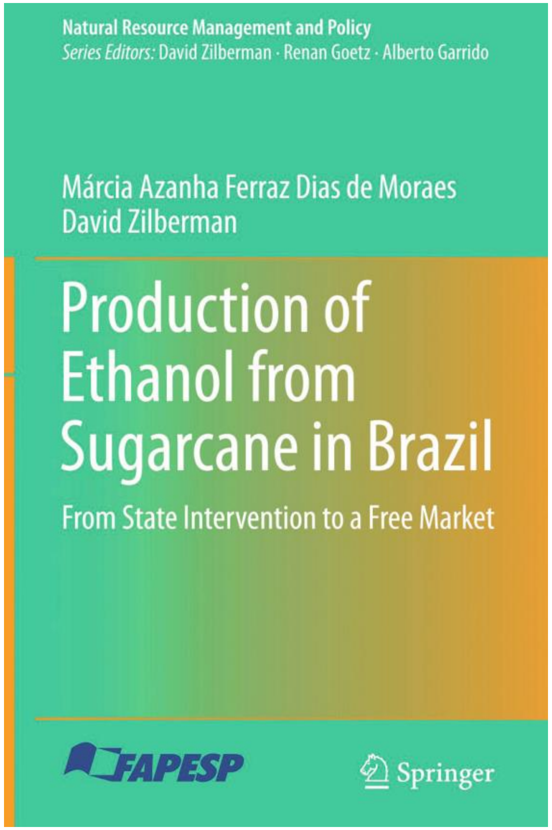
Biomass and Bioenergy
Volume 91, August 2016, Pages 116–125

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)

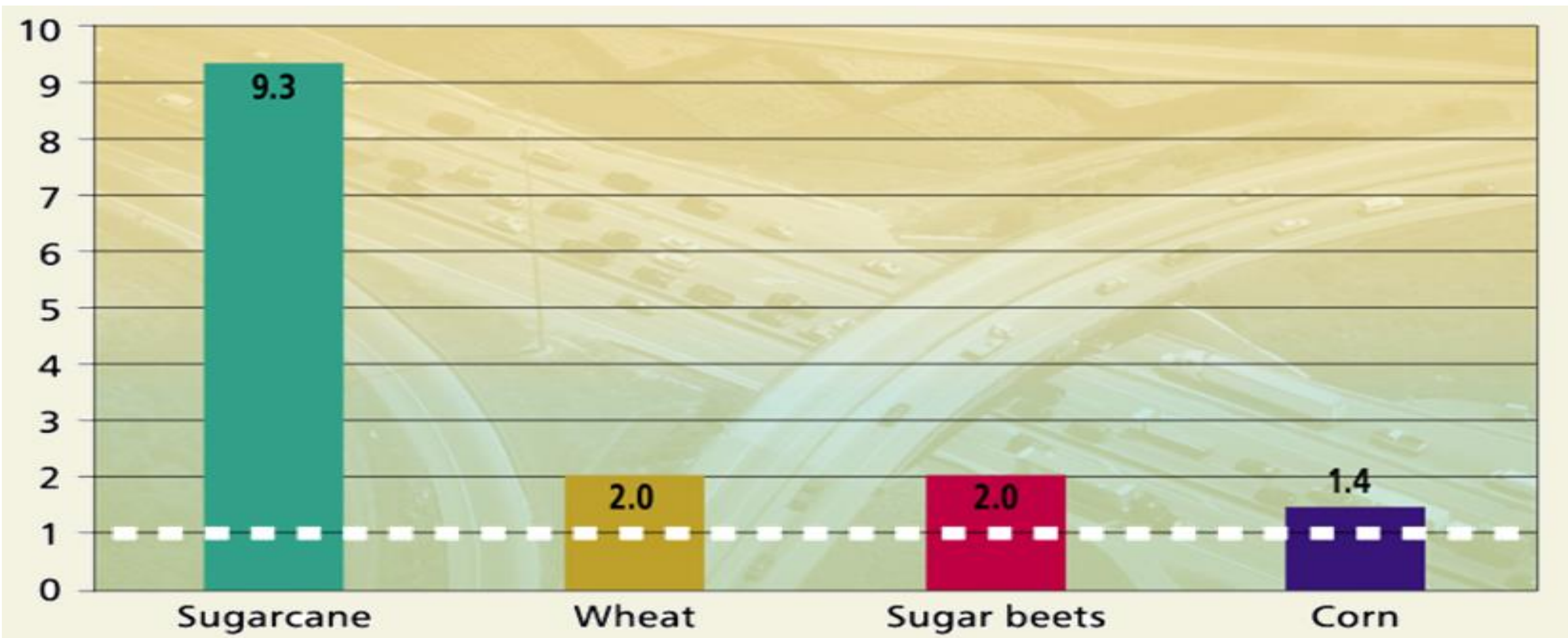
# Project main results

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

# Ethanol Energy Balance for Different Crops



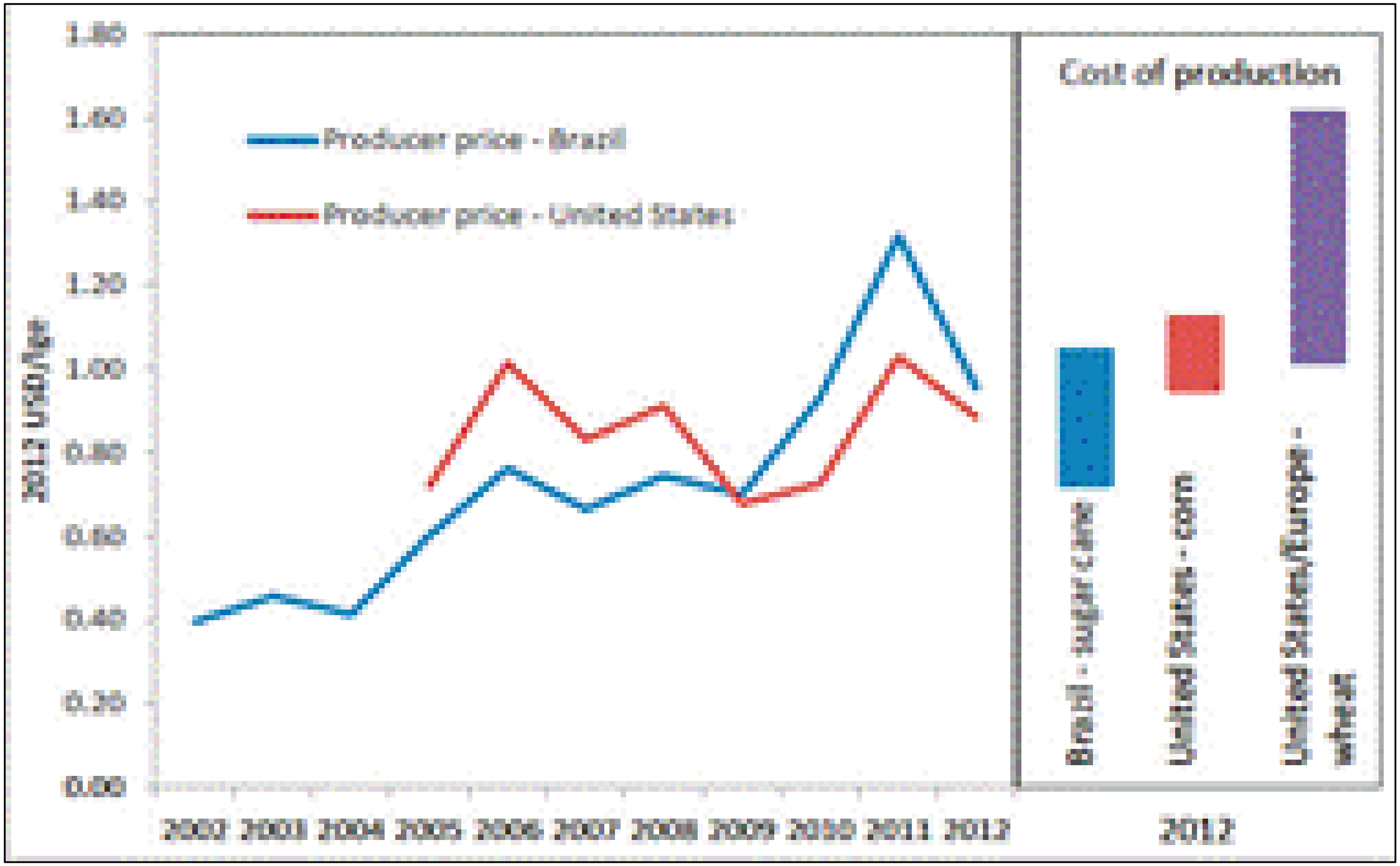

Source: World Watch Institute (2006) e Macedo et al. (2008).
Elaboration: UNICA

# *Avoided carbon emissions with gasoline replacement by ethanol*

| Matéria-prima | Emissões evitadas |
|---|---|
| Cana-de-açúcar | 89% |
| Milho | -30% a 38% |
| Trigo | 19% a 47% |
| Beterraba | 35% a 56% |
| Mandioca | 63% |
| Resíduos ligno-celulósicos* | 66,5-73% |

* Estimativa teórica, tecnologia em desenvolvimento
Fontes: Dai et al, 2006; EBAMM, 2005; IEA, 2004; Macedo et al, 2007 e Nguyen et al, 2007

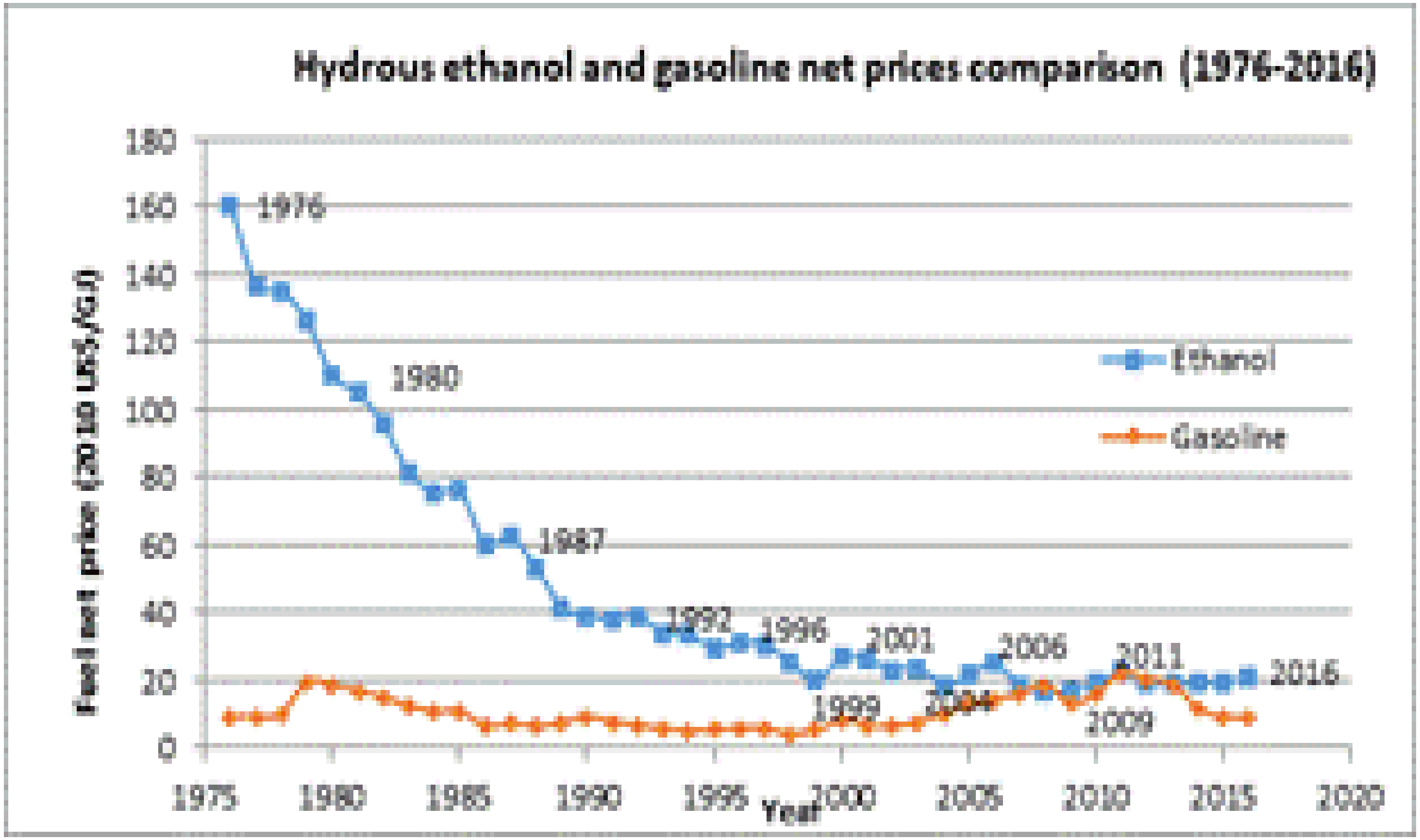
# *Ethanol production costs for different crops IRENA(2013)*



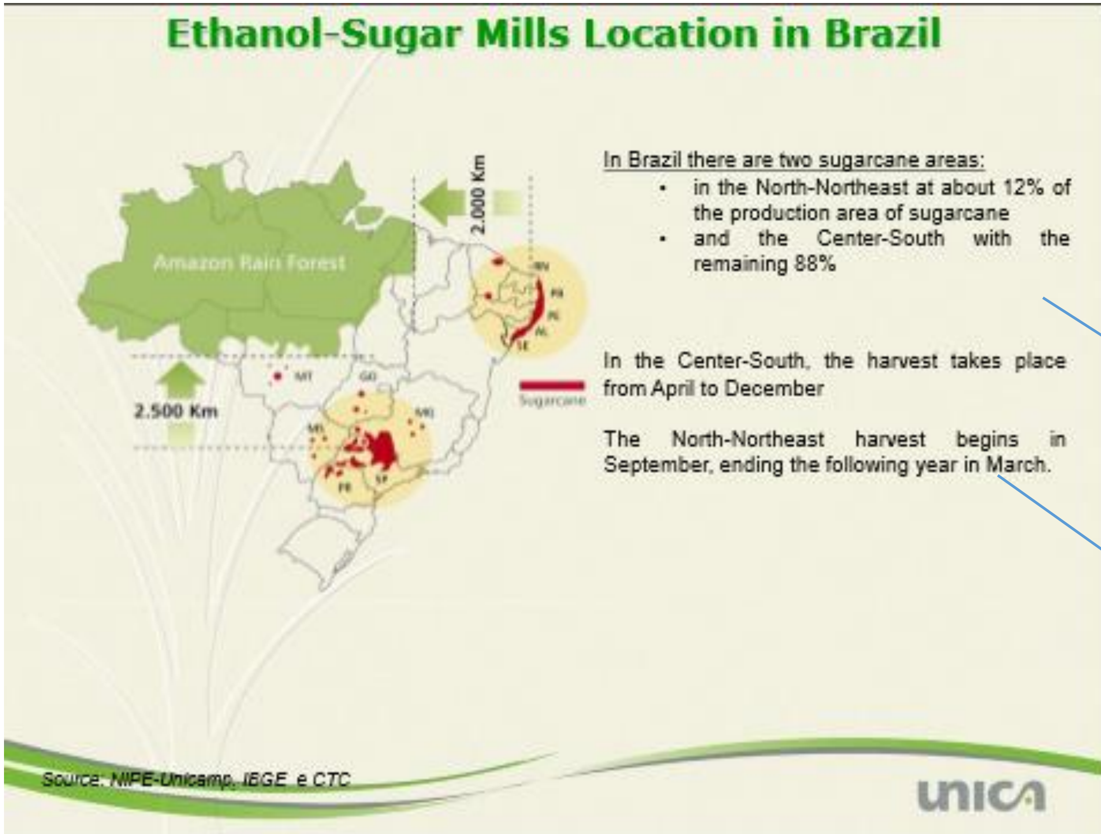
IEE USP

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

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




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




**2016/17 season**

**N-Northeast :**
**44,7 MM t cane**

**Center-South:**
**607,1 MM t cane**
**No irrigation**
**Ferti-irrigation w/ vinasse**

# *Water Resources & Bioenergy*

- Water Quantity
  - Water consumption on ethanol from sugarcane
  - Progress on efficiency
- Water Quality
  - Ethanol from sugarcane
  - Energy from urban and rural residues – sinergies with basic sanitation and water quality

*Water use in sugarcane ethanol production*
*Industrial phase*

**Average reduction on water use rate (catchment)**

1997: 5 m3 /t sugarcane

2004: 1.83 m3/t sugarcane

2013/14: 1.18 m3/tc

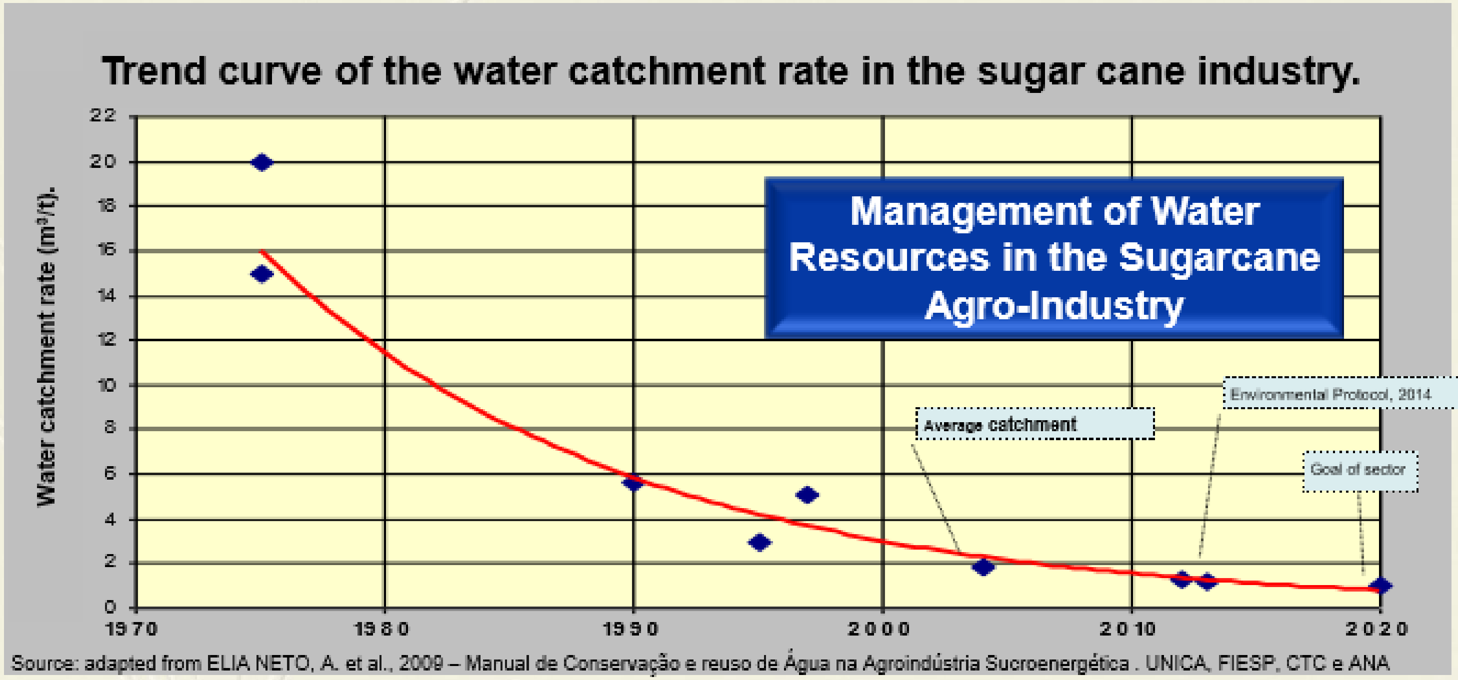
2016/17: 0.91 m3/tc (**some mills less than 0.7 m3/tc**)

2015 – Cetesb - 0.85 m3/tc - mandatory in Sao Paulo

- **Water recycling**
- **Higher efficiency** in water treatment/recycling: 98%
- Sugarcane **dry cleaning process (no water)**
- **Mechanical harvesting of green cane** – little need for cleaning

Source: Coelho, S. (Personal assessment)

# DECREASE WATER CATCHMENT



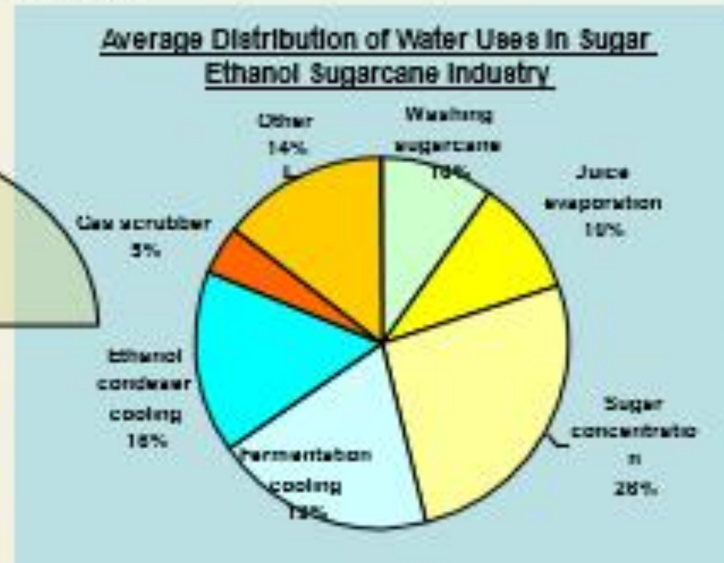

- The water catchment, which had been 15-20 m3 per ton of cane about four decades ago, has been minimized with the closing of the water systems to reuse.
- On average, the water catchment for industry, is about 2 m3 / ton of cane (data from 2005)
- The self imposed target is 1 m3 per ton of cane

# Management of Water Resources in the Sugarcane Agro-Industry

## Strategy: minimum water catchment and zero discharge

- reduction of use and practice of water reuse
- closed circuit
- wastewater for farming

90% of reuse with de average of water catchment of 2 m3/t




| Goals for water management | |
|---|---|
| Catchment ($m^3$/t.cane) | 1.0 |
| Consumption ($m^3$/t.cana) | 1.0 |
| Wastewater for river ($m^3$/t.cana) | zero |

There are mills that water catchment with lower rates (< 0.7 $m^3$ / t cane)

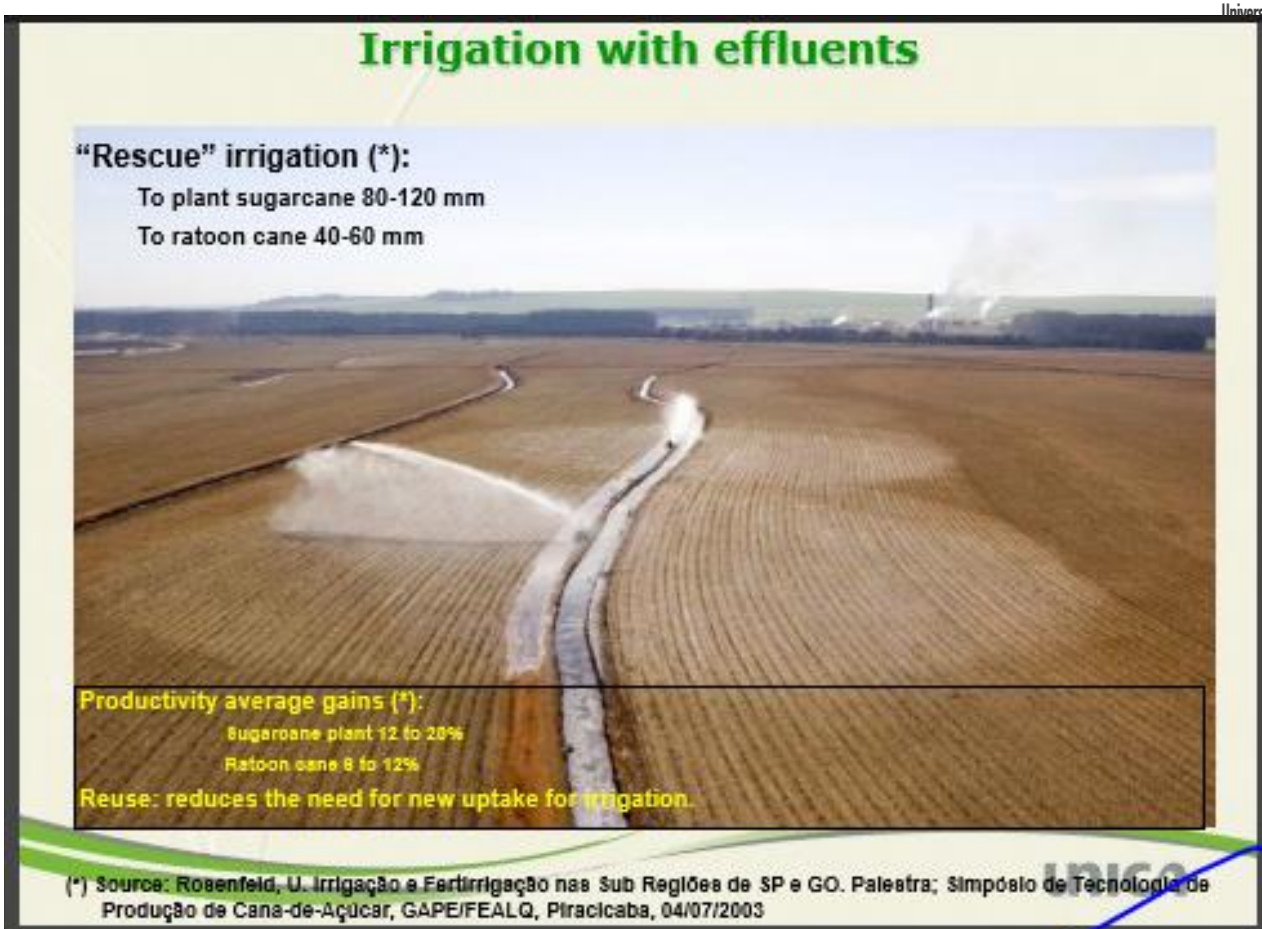
**Average use= 22 $m^3$/t.cana (in mill)**

unica

# *Water use in sugarcane ethanol production*
# *Agricultural phase*

a) No irrigation (98.4% of sugarcane crops = fertirrigation with vinasse – ANA, 2017)
b) No water discharge
c) Vinasse (by-product from ethanol distillation, 8-12 L/L of ethanol)
   - Current use: fertirrigation
   - Current trends: vinasse biodigestion - energy production

http://arquivos.ana.gov.br/institucional/spr/_LevantamentoCanaIrrigada_posCE_CEDOC_SemISBN2.pdf




**Workshop on "Examples of Positive Bioenergy and Water Relationships"**
***Royal Swedish Academy of Agriculture and Science (KSLA)***
Stockholm, 25-26 August 2015

# *Bioenergy & Water quality (1/2)*

1. Water quality in ethanol sector
   a) No water discharged

   b) Vinasse (by product from ethanol distillation)
   - Used for fertirrigation
   - Current trends: vinasse biodigestion - energy production

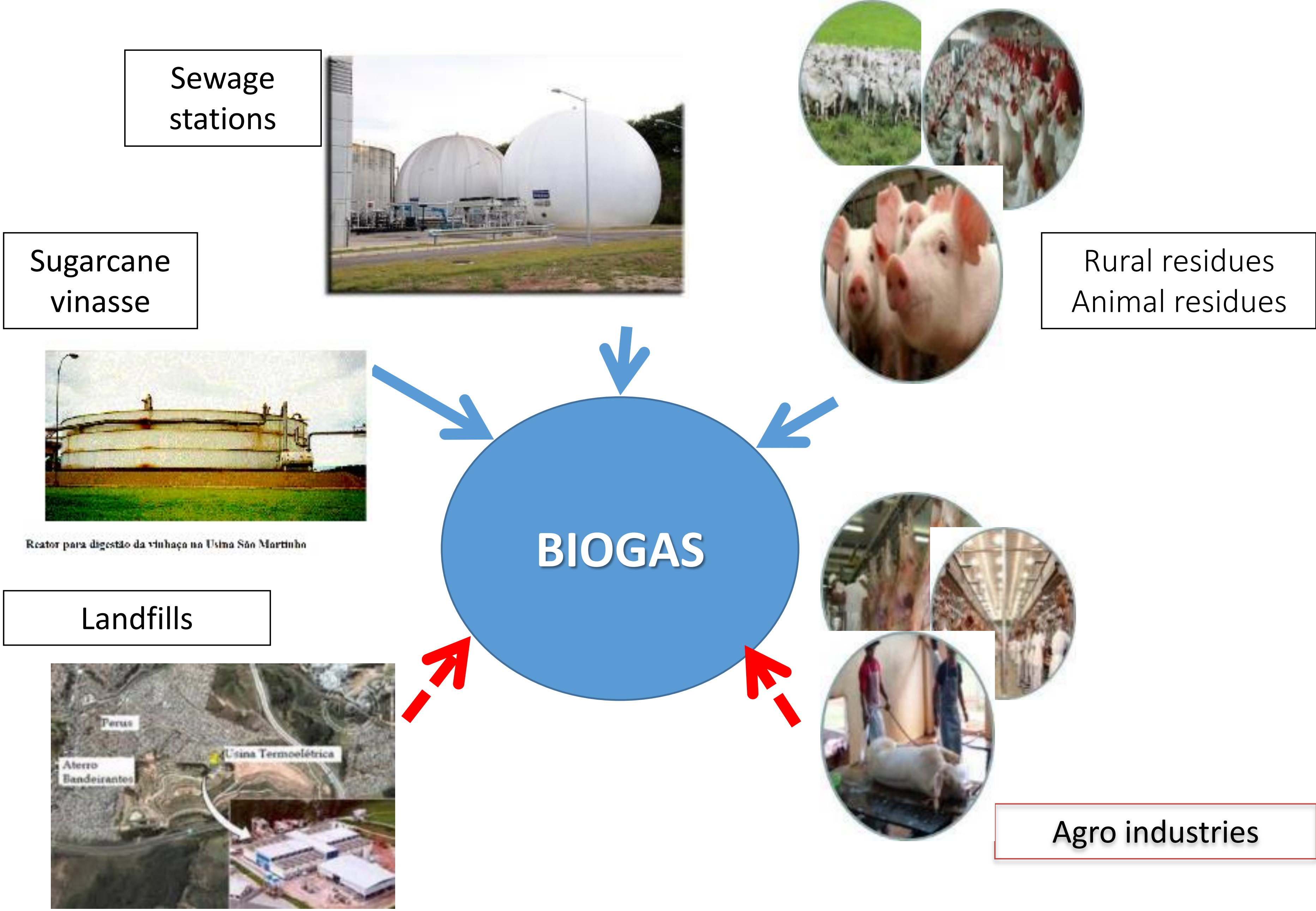
- Environmental Sao Paulo State regulation - CETESB/SP P4.231 – vinasse ferti-irrigation control

- Monitoring of underground water
- Control of the vinasse disposed in the soil (depending on potassium concentration in soil)

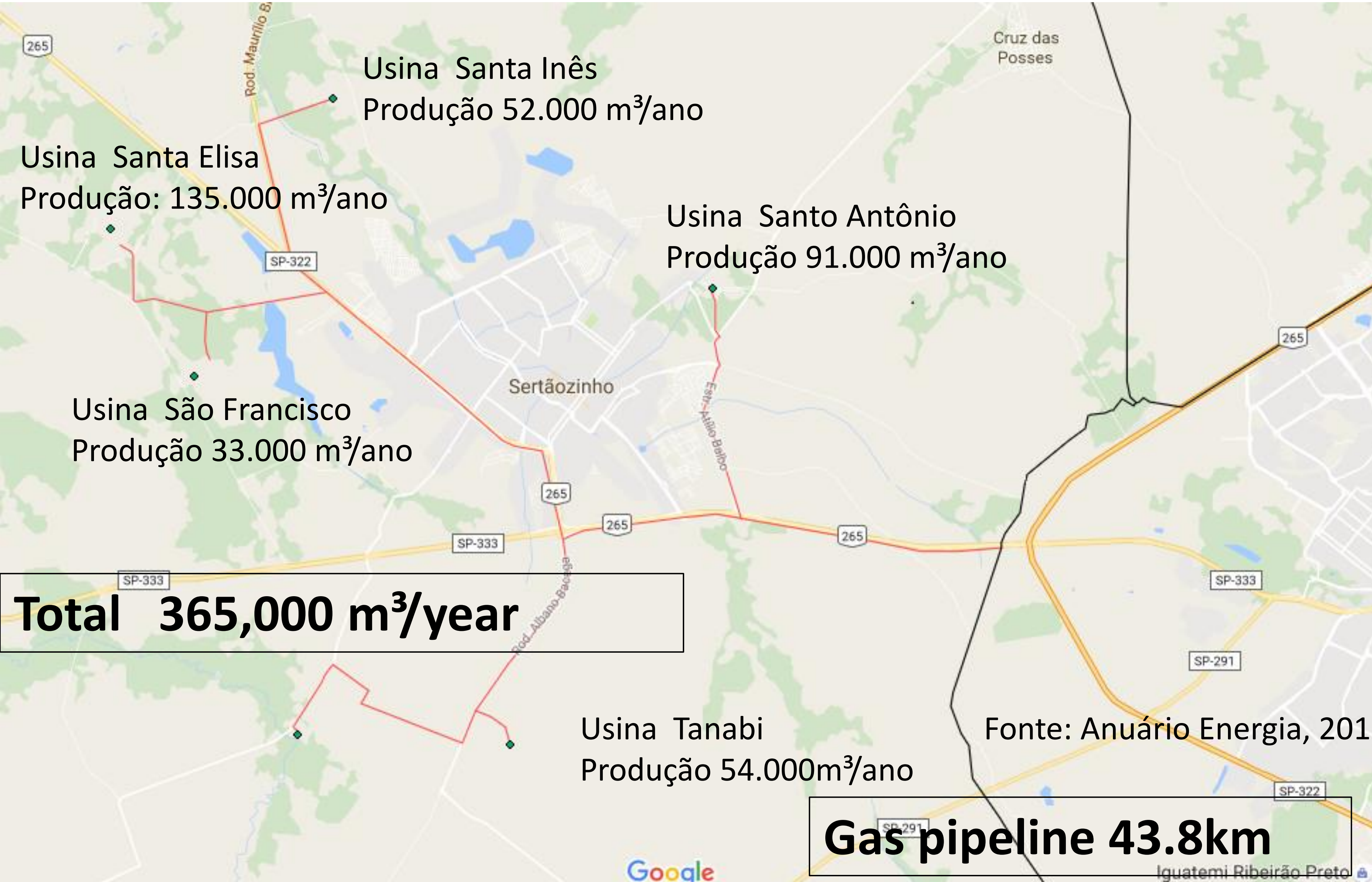
| | | |
|---|---|---|
| CETESB | VINHAÇA – CRITÉRIOS E PROCEDIMENTOS PARA APLICAÇÃO NO SOLO AGRÍCOLA | P4.231<br>Dez/2006 |

# Vinasse anaerobic digestion for energy conversion
GEO ENERGETICA – PARANA STATE

**Filter cake, tops and leaves, vinasse**
**2012 – Start-up - 4 MW**
**Expansion – 16 MW**
http://www.geoenergetica.com.br/perfil.php

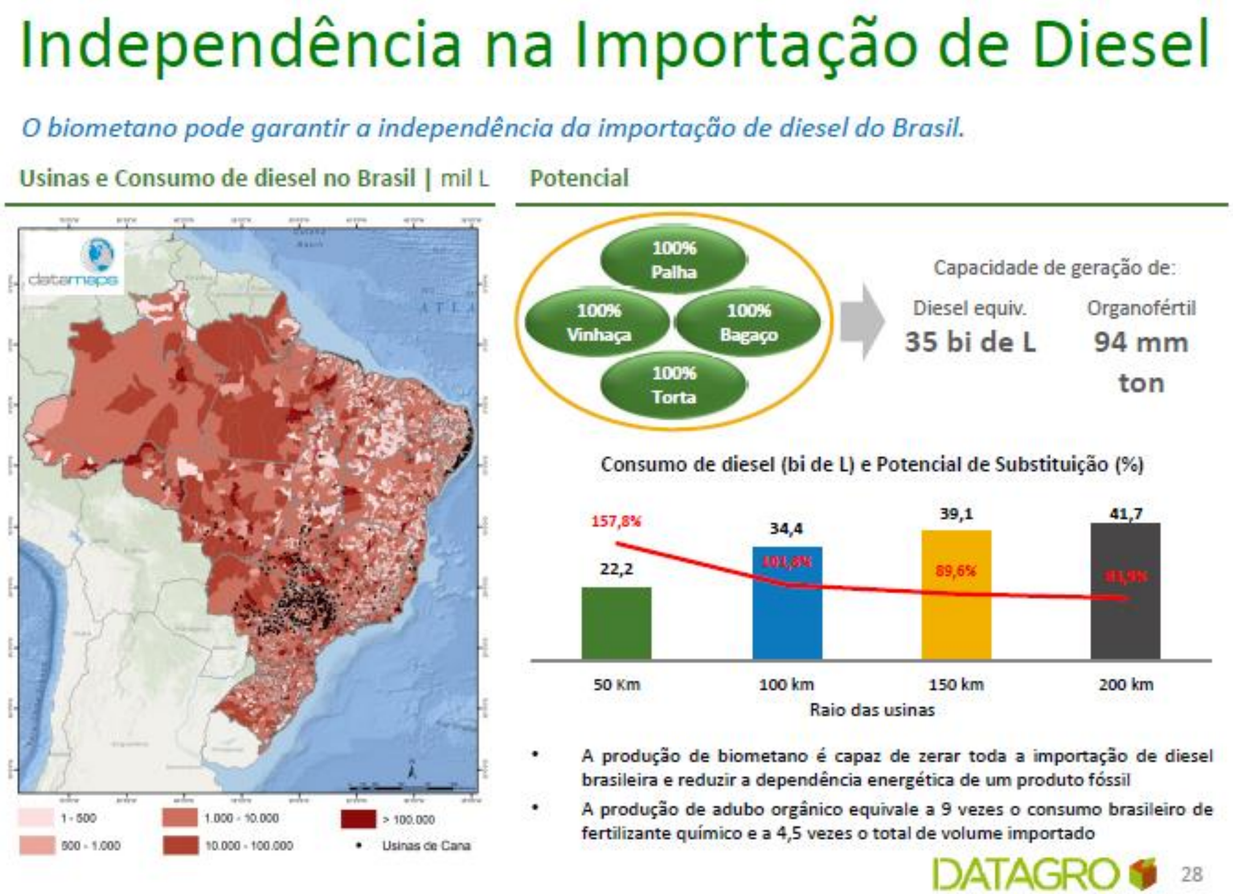

Sewage stations
Sugarcane vinasse
Reator para digestão da vinhaça na Usina São Martinho
Landfills
Perus
Usina Termoelétrica
Aterro Bandeirantes
BIOGAS
Rural residues
Animal residues
Agro industries

# Biogas from vinasse potential in Sertãozinho region



# Biomethane & Independence on diesel imports

## Biomethane from vinasse – possible replacement of 59.7% of diesel consumption in SP



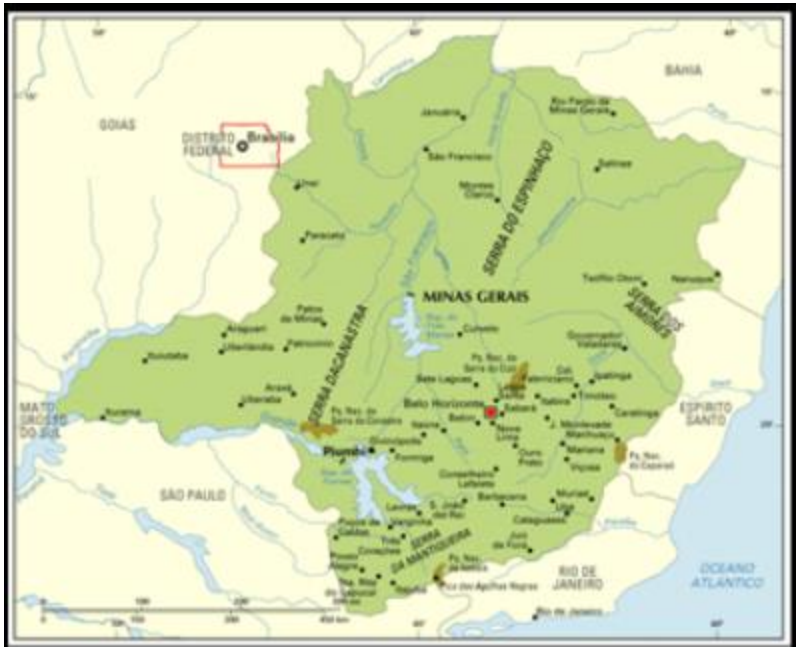

**Source: Nastari, P. (2016). Workshop on Perspectives of the biomethane contribution to increase NG offer. September 14, 2016. GBIO/RCGI/USP**

# *Water quality (2/2) – Sinergies with Basic Sanitation*

2. Urban residues - MSW

- Furnas Electric Co. (Minas Gerais State)
- Municipalities around the lake
- Inadequate disposal of MSW – contamination of waters

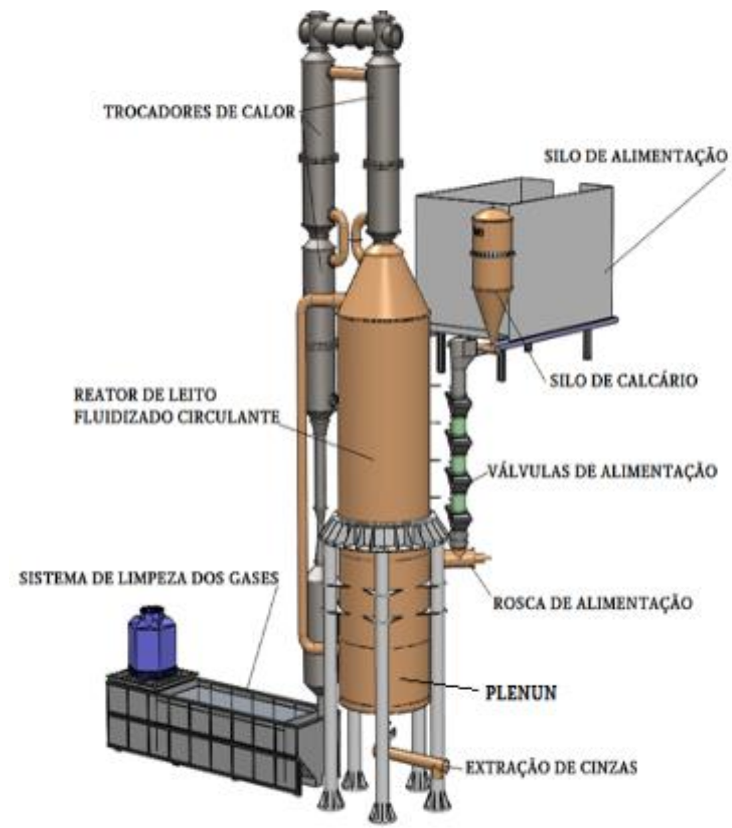
# *Water quality (2/2) Sinergies with Basic Sanitation*




Localização de Boa Esperança em Minas Gerais

# *Water quality (2/2) – Sinergies with Basic Sanitation*

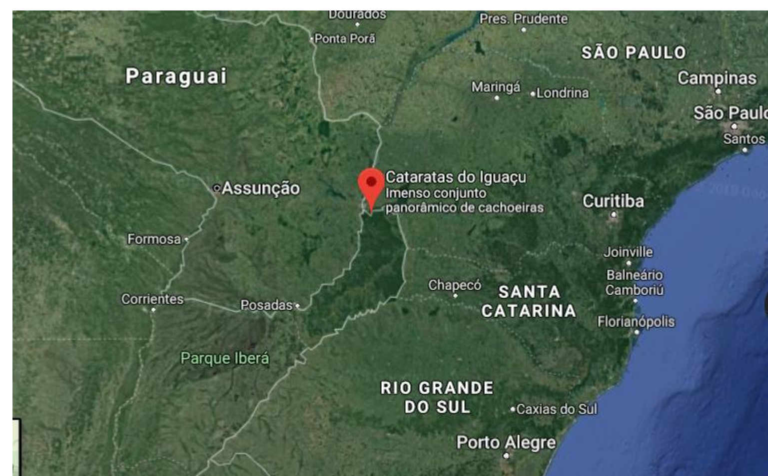
2. Urban residues - MSW
    - Furnas Electric Co. (Minas Gerais State)
    - Waste to energy plant – Municipality of Boa Esperança
        - 1 MWe – MSW gasification plant (syngas to power)
        - Brazilian technology – CARBOGAS fluidized bed gasifier



# *Water quality (2/2) – Sinergies with Basic Sanitation*

3. Rural residues

- Small farmers – inadequate disposal of animal waste
- Possible contamination of rivers and lakes – Iguassu falls
- Itaipu Electric Co – Ajuricaba Basin
    - **Local** Farmers (swin and cow producers)
    - Biodigestion plants
    - Biogas for electricity production
    - Biogas for cooking
    - 2017 - Tests of biogas in light and heavy vehicles




https://www.google.com.br/maps/

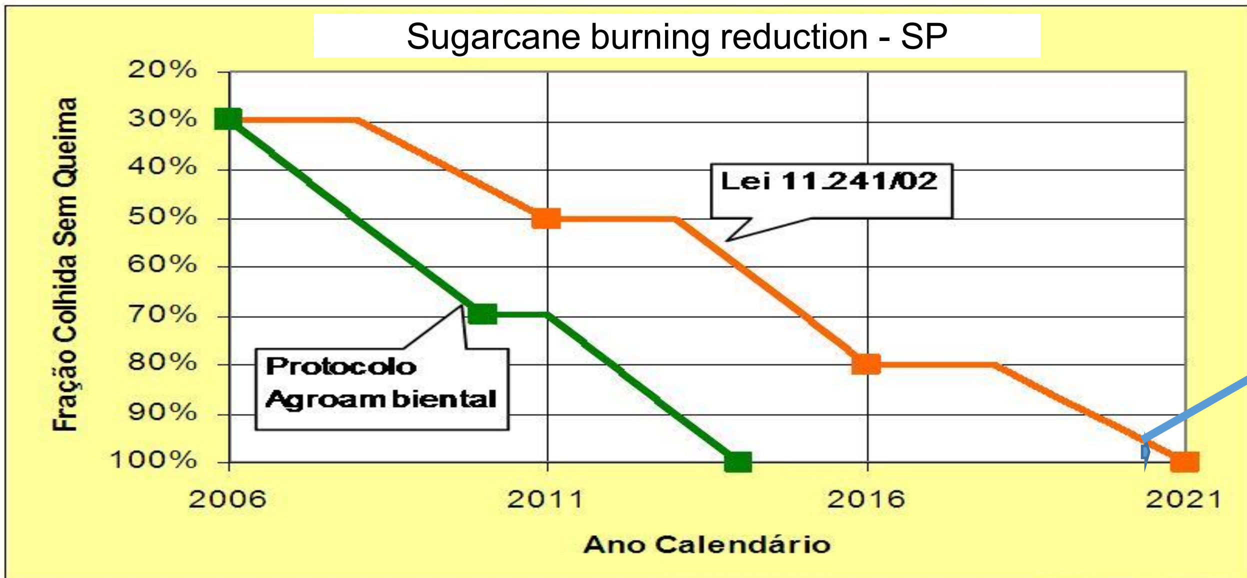
GRUPO DE PESQUISA EM BIOENERGIA




Source: Ajuricaba Project – Visit Suani Coelho (2017)

# *Biofuels x Air pollution - Energy use of tops and leaves*

Phase out of sugarcane burning in Brazil (SP, Center West)




**2017 - 98% of the sugarcane mills already harvest cane without burning**

Other states – similar legislation – ex. Mato Grosso - 2024

# Renewable energy from biomass
# Bioelectricity from sugarcane residues

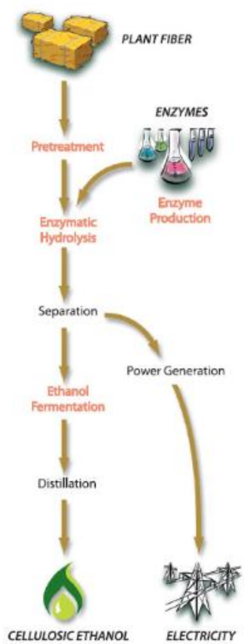

**In 2016**

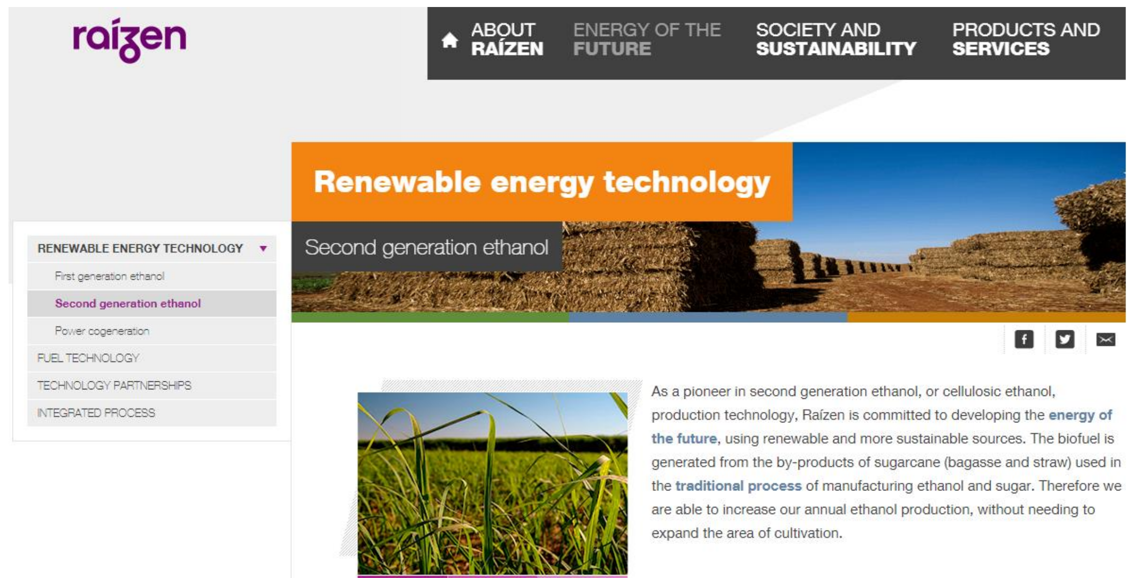
- ❑ **378 sugarcane mills**
- ❑ **44% - electricity surplus - 166 mills**
- ❑ **56% selfproducers: 212 mills**

Source: EPE e UNICA (2017).

# *Cane residues for 2G Ethanol Raizen Group – Sao Paulo*

Cellulosic Ethanol Process




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.

# Land use in Brazil - 2017

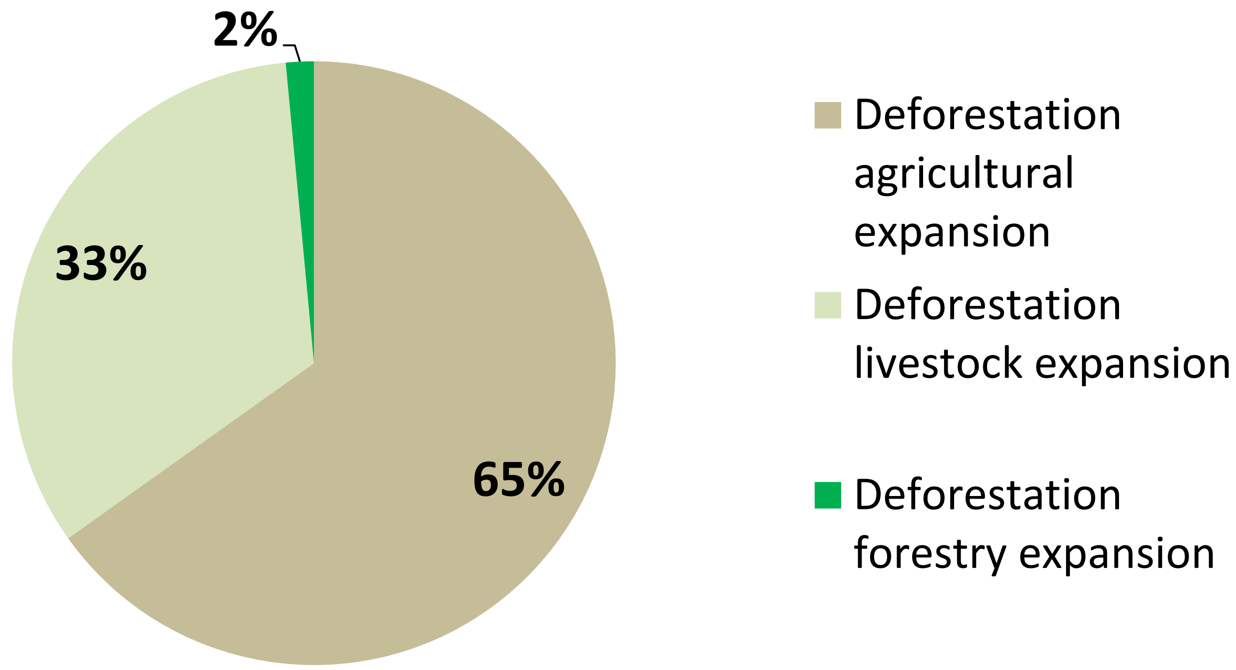
| Millions of hectares | |
|---|---|
| Brazil | 851 |
| *Arable land* | 354,8 |
| **1. Total cultivated area** | **84,2** |
| Soy | 33,2 |
| Corn | 15,2 |
| Grains | 10,1 |
| Citrus | 9,3 |
| Sugar cane | 8,6 |
| Forestry production | 7,8 |
| **2. Grasslands** | **168,0** |
| **3. Available area (degraded)**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

Ethanol = 4.3 MM ha

cattle

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

# Deforestation by type of crop in Brazil




Source: (Escobar, 2016). Based on (IBGE, 2015)

# 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

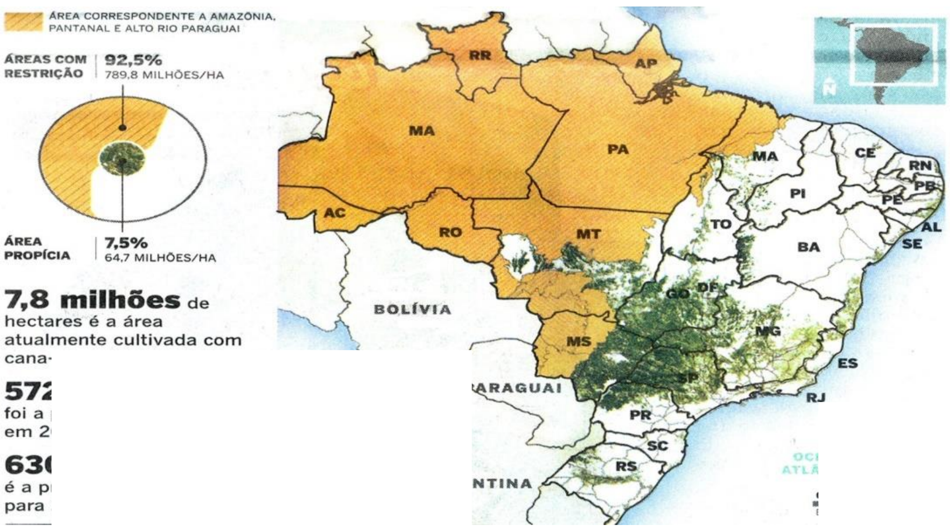
| Current situation | | |
|---|---|---|
| **Area** | **Heats of cattle** | **Density (Heats of cattle/ha)** |
| 172 million hectares | 169 million | 0,98 |
| **Prospects** | | |
| 108 million hectares | 169 million heats of cattle | 1,56 (SP - 2008) |

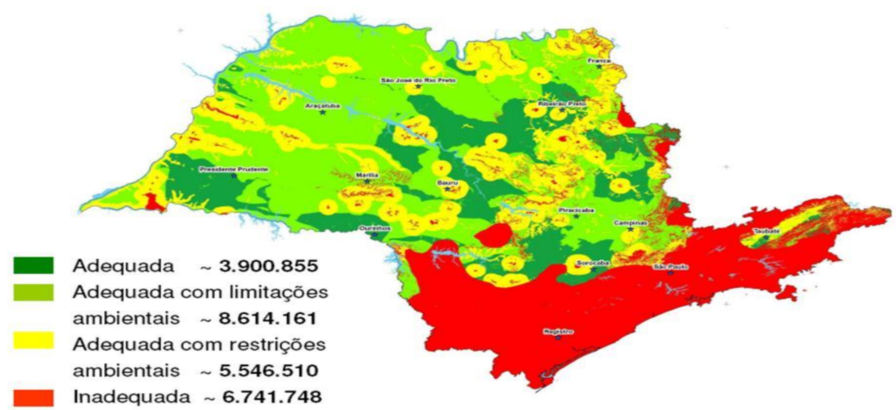
64 million hectares will be available !

Biofuels

Food

# Zoneamento Agro-ecológico da Cana



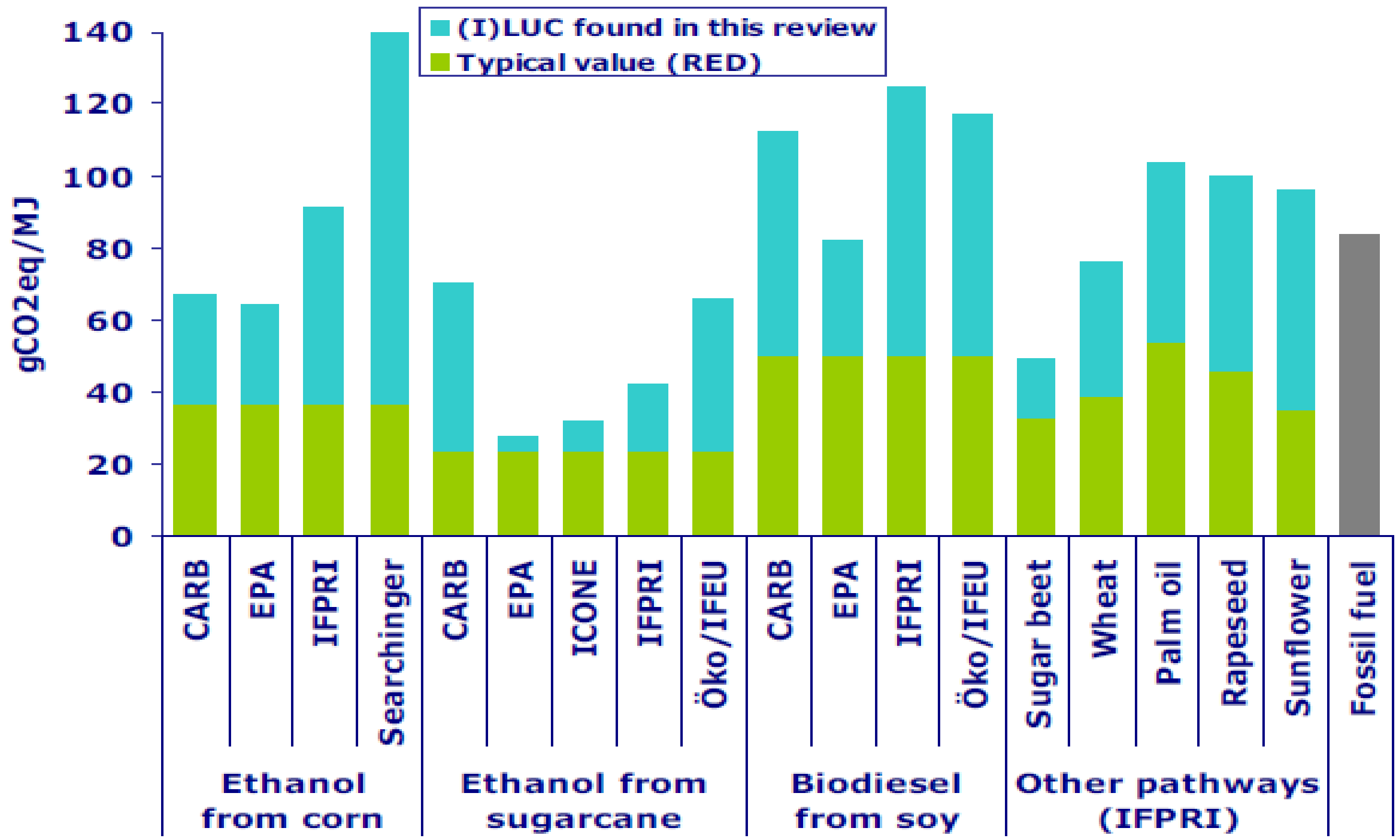
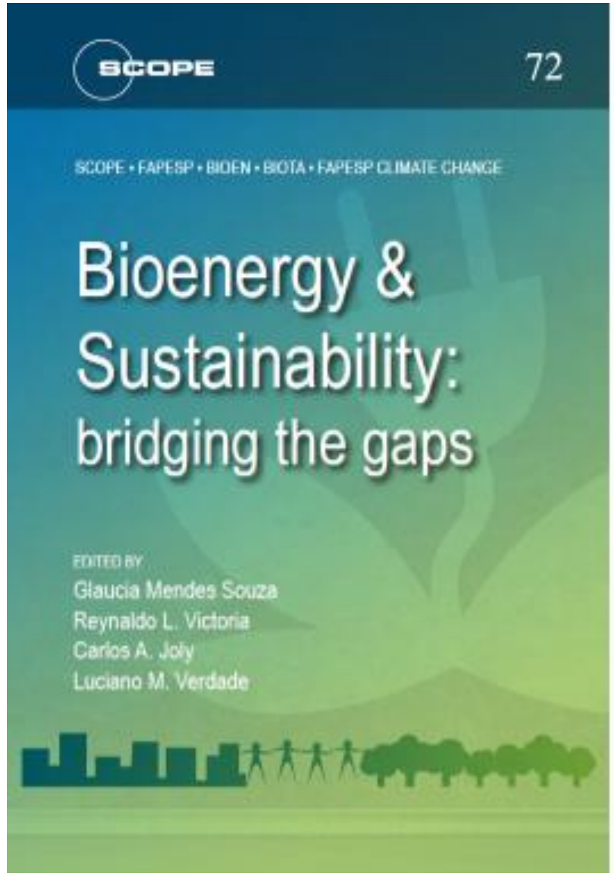



Figure 2 - 2 Graphical representation of the emissions caused by (I)LUC, direct and indirect land use change, for different biofuel pathways and different studies. For reference, typical non-land-use change emissions for the different pathways and a fossil reference from the EU Renewable Energy Directive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

# Teses recentes

- Mauricio Roberto Cherubin, ESALQ/USP, 2016. ***Soil quality response to land-use change for sugarcane expansion in Brazil*** (USP Best Thesis Award 2017)

- Ana Cristina Guimarães Donke. Avaliação do desempenho ambiental e energético na produção de etanol de cana, milho e sorgo em uma unidade integrada pela abordagem de ciclo de vida. ***Evaluation of environmental and energetic performance in ethanol production from sugarcane, corn and sorghum in an integrated mill using LCA***. Dissertação de mestrado (Master thesis). PPGE/IEE/USP. 2016.

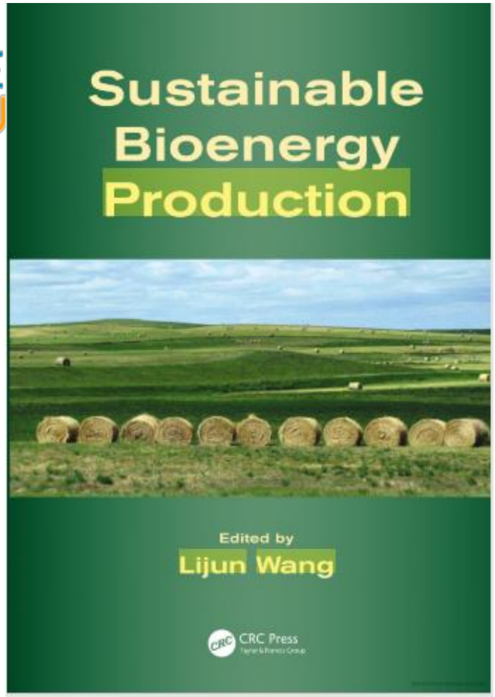



2013
http://bioenfapesp.org/scopebioenergy/images/chapters/bioenergy_sustainability_scope.pdf

https://link.springer.com/referenceworkentry/10.1007/978-1-4939-2493-6_312-4#howtocite


Goldemberg J., Coelho S.T., Guardabassi P., Nastari P.M. (2017) Bioethanol from Sugar: The Brazilian Experience. In: Meyers R. (eds) Encyclopedia of Sustainability Science and Technology. Springer, New York, NY


| DOI | Publisher Name | Online ISBN |
|---|---|---|
| https://doi.org/10.1007/978-1-4939-2493-6 | Springer, New York, NY | 978-1-4939-2493-6 |




CRC Press
Taylor & Francis Group
6000 Broken Sound Parkway NW, Suite 300
Boca Raton, FL 33487-2742


Version Date: 20131217

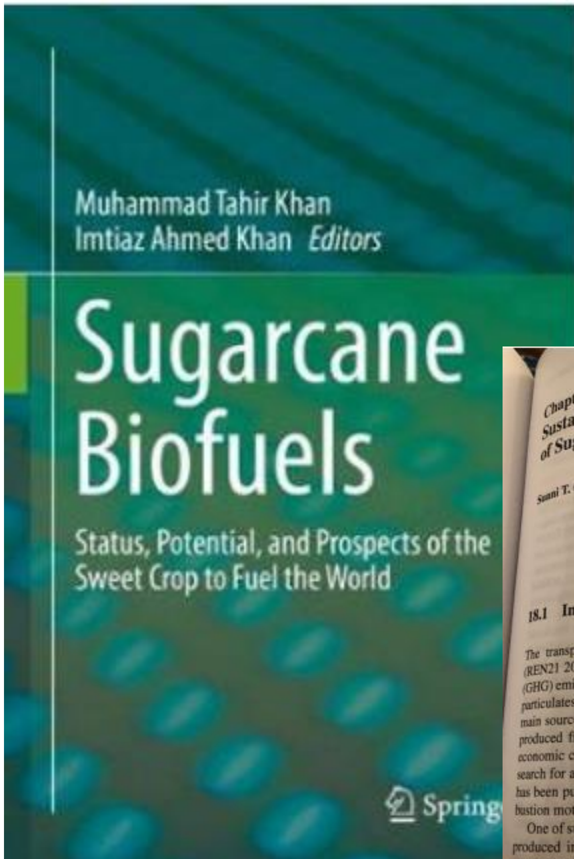
International Standard Book Number-13: 978-1-4665-0556-8 (eBook - PDF)

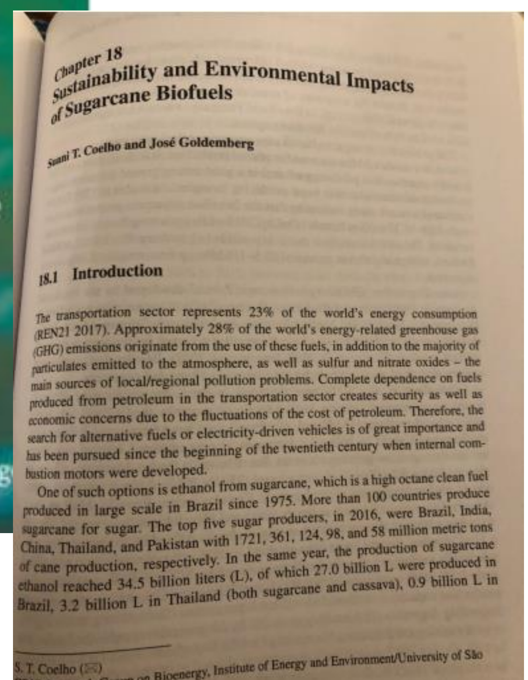
WANG, Lijun (Ed). Sustainable Bioenergy Production. In: Goldemberg, José; Coelho, Suani T.; Nastari, Plinio M.; Guardabassi, Patrícia. Production and supply logistics of sugarcane as an energy feedstock. Boca Raton, CRC Press, 2014. p. 213-222.

https://books.google.com.br/books?id=gL7MBQAAQBAJ&pg=PR3&lpg=PR3&dq=Production+and+supply+logistics+of+sugarcane+wang+lijun&source

IEE USP

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



Chapter 18
Sustainability and Environmental Impacts of Sugarcane Biofuels

Suani T. Coelho and José Goldemberg

18.1 Introduction

The transportation sector represents 23% of the world's energy consumption (REN21 2017). Approximately 28% of the world's energy-related greenhouse gas (GHG) emissions originate from the use of these fuels, in addition to the majority of particulates emitted to the atmosphere, as well as sulfur and nitrate oxides – the main sources of local/regional pollution problems. Complete dependence on fuels produced from petroleum in the transportation sector creates security as well as economic concerns due to the fluctuations of the cost of petroleum. Therefore, the search for alternative fuels or electricity-driven vehicles is of great importance and has been pursued since the beginning of the twentieth century when internal combustion motors were developed.

One of such options is ethanol from sugarcane, which is a high octane clean fuel produced in large scale in Brazil since 1975. More than 100 countries produce sugarcane for sugar. The top five sugar producers, in 2016, were Brazil, India, China, Thailand, and Pakistan with 1721, 361, 124, 98, and 58 million metric tons of cane production, respectively. In the same year, the production of sugarcane ethanol reached 34.5 billion liters (L), of which 27.0 billion L were produced in Brazil, 3.2 billion L in Thailand (both sugarcane and cassava), 0.9 billion L in

S. T. Coelho (✉)
GBIO/Research Group on Bioenergy, Institute of Energy and Environment/University of São

IEE USP

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

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

Universidade de São Paulo
Escola Superior de Agricultura "Luiz de Queiroz"

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

**Manuel Moreno Ruiz Poveda**

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

Piracicaba
2019