COPPE

Alberto Luiz Coimbra Institute for Graduate Studies
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Energy Planning Program, COPPE
Universidade Federal do Rio de Janeiro

Bioenergy in Brazil

current status and future perspectives

Prof. Roberto Schaeffer, Ph.D.

Canon Institute of Global Studies, Tokyo, Japan, August 3, 2017

CENERGIA

I sincerely have to thank Joana Portugal-Pereira, a former posdoc working in our research group under my supervision, and now at the Imperial College, London, working in the Technical Support Unit (TSU) of the IPCC, for most of these slides, which I borrowed from her and which were only slightly modified. She did most of the hard work here. And thanks to Camila Ludovique, a Ph.D. student of mine, who also helped to put these slides together.

Outline

01 Biofuels status today

Brazil and USA: key ethanol producers
Brazil, EU and Indonesia: key biodiesel producers

02 Biofuels programs

Brazilian Pró-álcool and Biodiesel programs
USA ethanol program
EU renewable energy policy

03 Sustainability of biofuels production

Fossil fuel replacement
GHG reduction
Land use change
Water footprint

04 Economic perspectives

Cost and price of biofuels
Economic impacts

05 Final considerations

key definitions before starting…

Biomass

organic matter derived from vegetal and animal materials

Liquid biofuels

fuels produced from biomass

Ethanol: ethyl alcohol that is blended with gasoline used in Otto-cycle engines

Biodiesel: Fatty acid methyl esters (FAME) that are blended with diesel used in compression-ignition engines

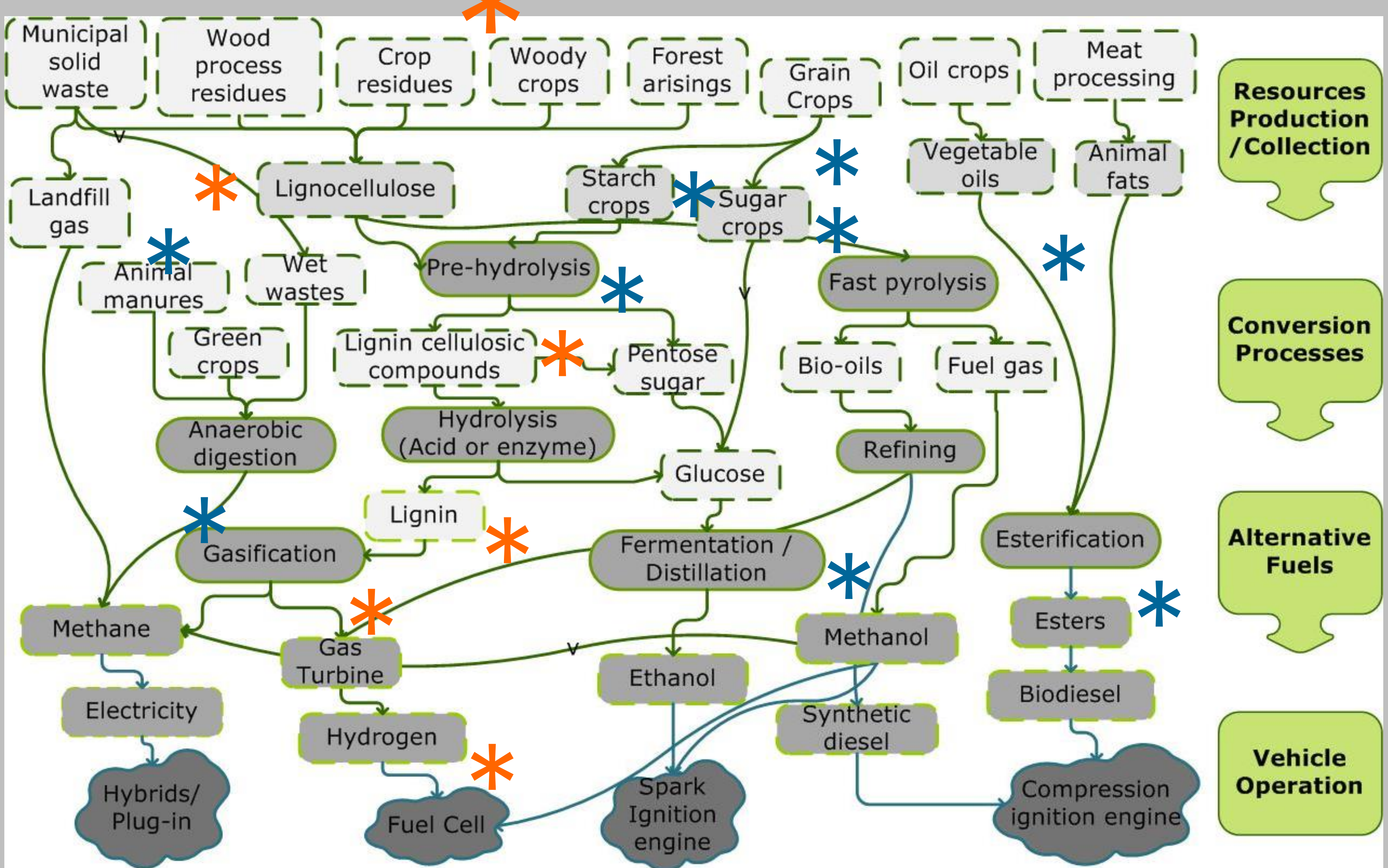
Biofuels technologies

Conventional: well established processes available at commercial scale → sugar- and starch-based ethanol, vegetable and animal biodiesel, biogas from anaerobic digestion

Advanced: pathways that are still in the R&D/pilot stage (e.g.: hydrotreated vegetable oil, cellulosic ethanol, biomass-to-liquid (BtL) diesel, algae biodiesel)

key definitions before starting…

– Conventional processes
Advanced processes



Where did all start?

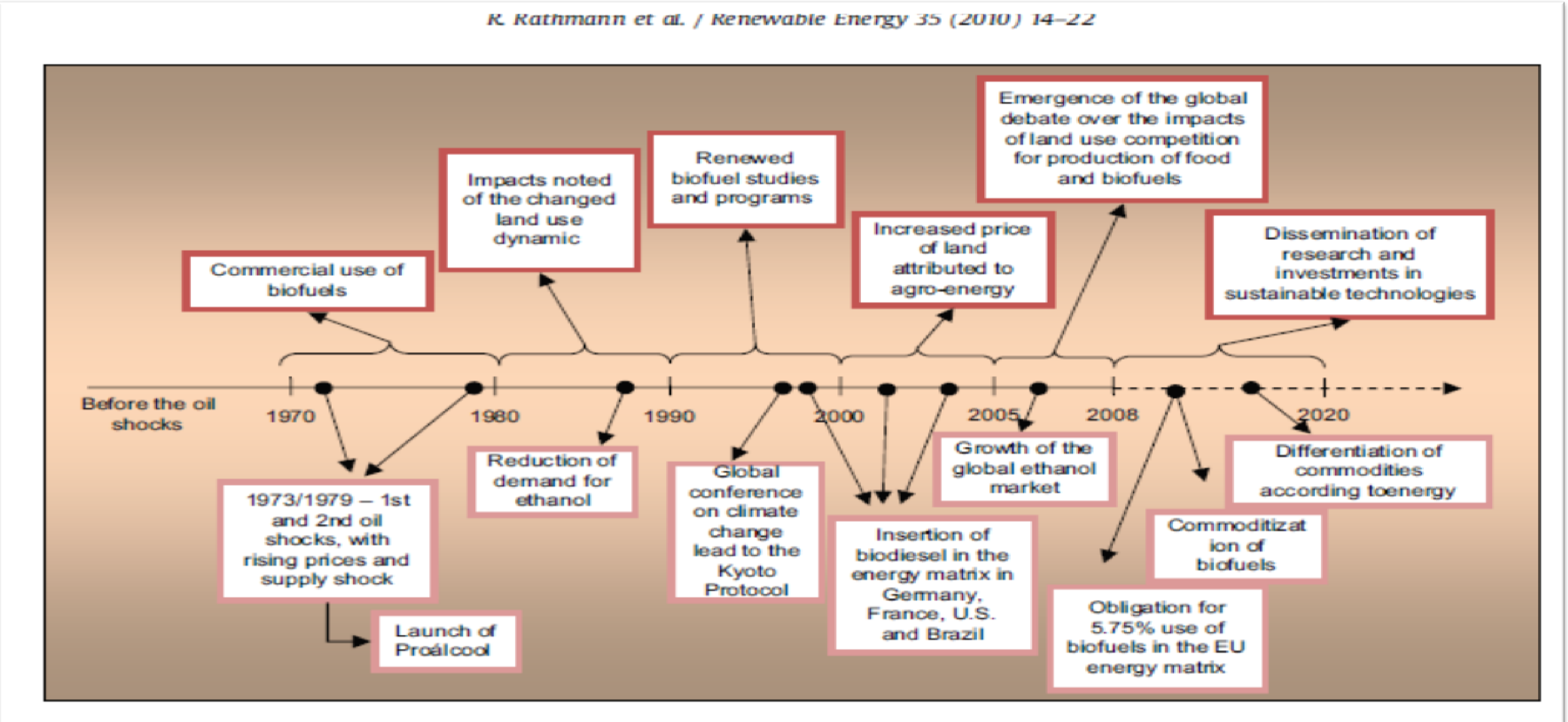


Fig. 1. Historical evolution and research on agro-energy and biofuels [8,10].

Where did we start?

ELSEVIER

Energy Policy 35 (2007) 5411–5421

ENERGY POLICY

www.elsevier.com/locate/enpol

Viewpoint

Can one say ethanol is a real threat to gasoline?

Alexandre Szklo*, Roberto Schaeffer, Fernanda Delgado

Energy Planning Program, Graduate School of Engineering, Federal University of Rio de Janeiro, Centro de Tecnologia, Bloco C, Sala 211, Cidade Universitária, Ilha do Fundão, Rio de Janeiro, RJ 21941-972, Brazil

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Where did we start?

Renewable Energy 35 (2010) 14–22

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Renewable Energy

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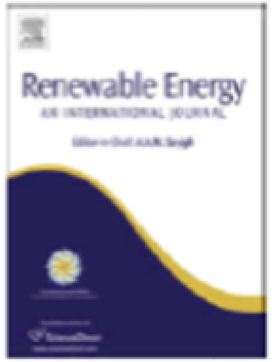

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Review

Land use competition for production of food and liquid biofuels: An analysis of the arguments in the current debate

Régis Rathmann*, Alexandre Szklo, Roberto Schaeffer

Energy Planning Program, Graduate School of Engineering, Federal University of Rio de Janeiro, Centro de Tecnologia, Bloco C, Sala 211, Cidade Universitária, Ilha do Fundão, Rio de Janeiro, RJ 21941-972, Brazil

Where did we start?

Energy Policy 39 (2011) 3154–3162

Contents lists available at ScienceDirect

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Energy Policy

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

ENERGY POLICY

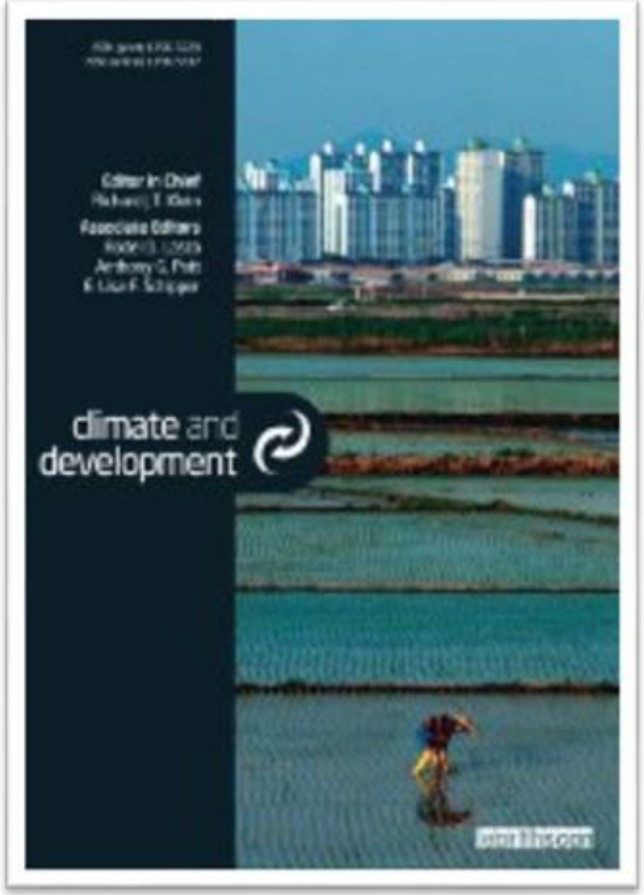
Can new legislation in importing countries represent new barriers to the development of an international ethanol market?

Raquel R. de Souza [a,*], Roberto Schaeffer [a], Irineu Meira [b]

[a] Energy Planning Program, Graduate School of Engineering Federal University of Rio de Janeiro Technology Center, Block C, Room 211—University City, Ilha do Fundão, Rio de Janeiro, RJ 21941-972, Brazil

[b] Consultant Rua Manduba 145, Alto da Boa Vista, São Paulo, SP 04747-170, Brazil

Where did we start?



Climate and Development

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/tcld20

Emulating new policy goals into past successes: Greenhouse gas emissions mitigation as a side effect of biofuels programmes in Brazil

Christianne Maroun [a] & Roberto Schaeffer [a]

[a] Federal University of Rio de Janeiro, Environment and Energy Planning, Rio de Janeiro, Brazil

Available online: 24 Apr 2012

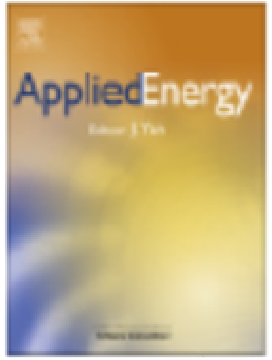
Where did we start?

Applied Energy 97 (2012) 91–100

Contents lists available at SciVerse ScienceDirect

Applied Energy

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



Targets and results of the Brazilian Biodiesel Incentive Program – Has it reached the Promised Land?

Régis Rathmann *, Alexandre Szklo, Roberto Schaeffer

Energy Planning Program, Graduate School of Engineering, Federal University of Rio de Janeiro, Centro de Tecnologia, Bloco C, Sala 211, Cidade Universitária, Ilha do Fundão, Rio de Janeiro, RJ 21941-972, Brazil

Where did we start?

International Journal of Greenhouse Gas Control 52 (2016) 270–292

Contents lists available at ScienceDirect

International Journal of Greenhouse Gas Control

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

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Technical potential and abatement costs associated with the use of process emissions from sugarcane ethanol distilleries for EOR in *offshore* fields in Brazil

CrossMark

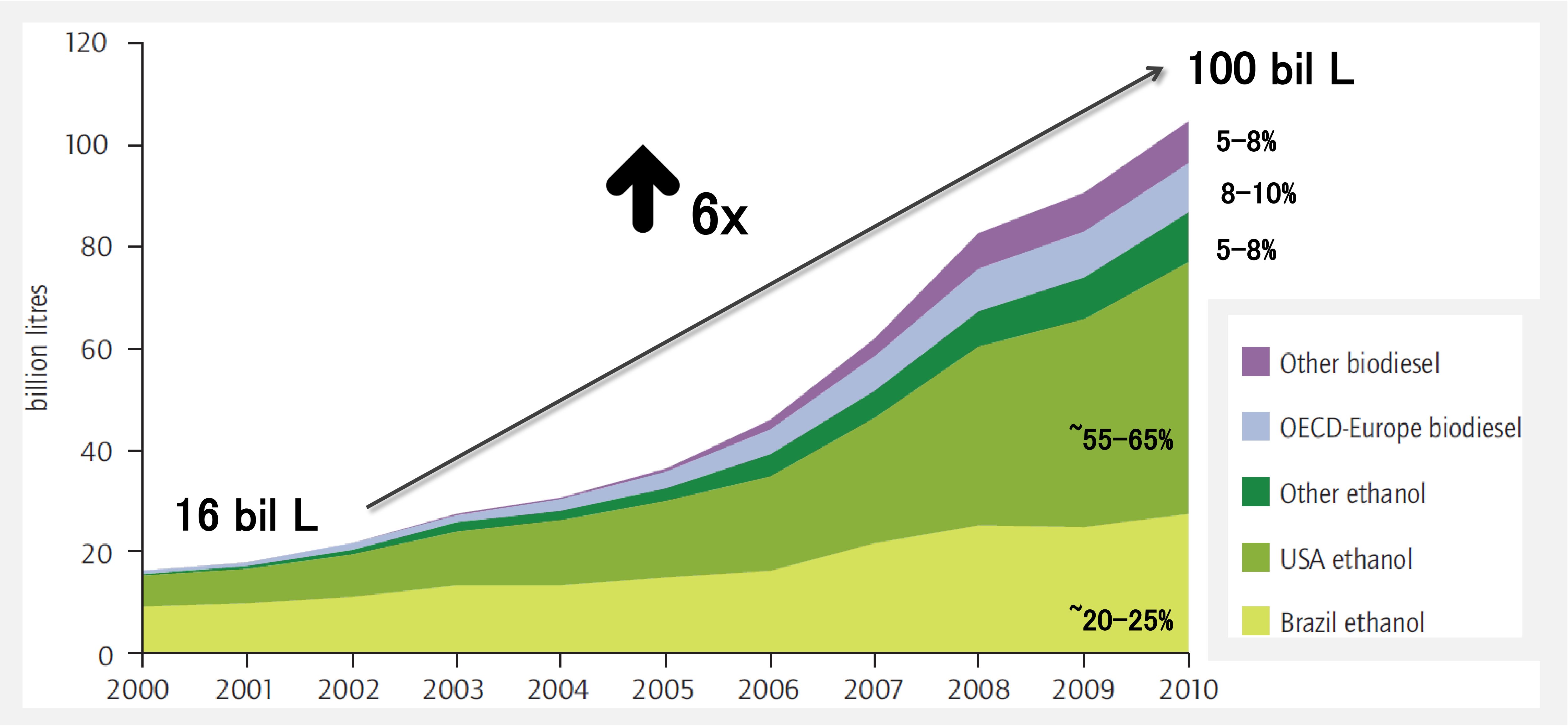
Paulo R. de C. Merschmann[a,*], Alexandre S. Szklo[b], Roberto Schaeffer[b]

[a] *Production Engineering Department, Federal Center of Technological Education Celso Suckow da Fonseca, Maracanã Avenue, 229, Maracanã, Rio de Janeiro, RJ 20271-110, Brazil*

[b] *Energy Planning Program, Graduate School of Engineering, Federal University of Rio de Janeiro, Centro de Tecnologia, Bloco C, Sala 211 Cidade Universitária, Ilha do Fundão, Rio de Janeiro, RJ 21941-972, Brazil*

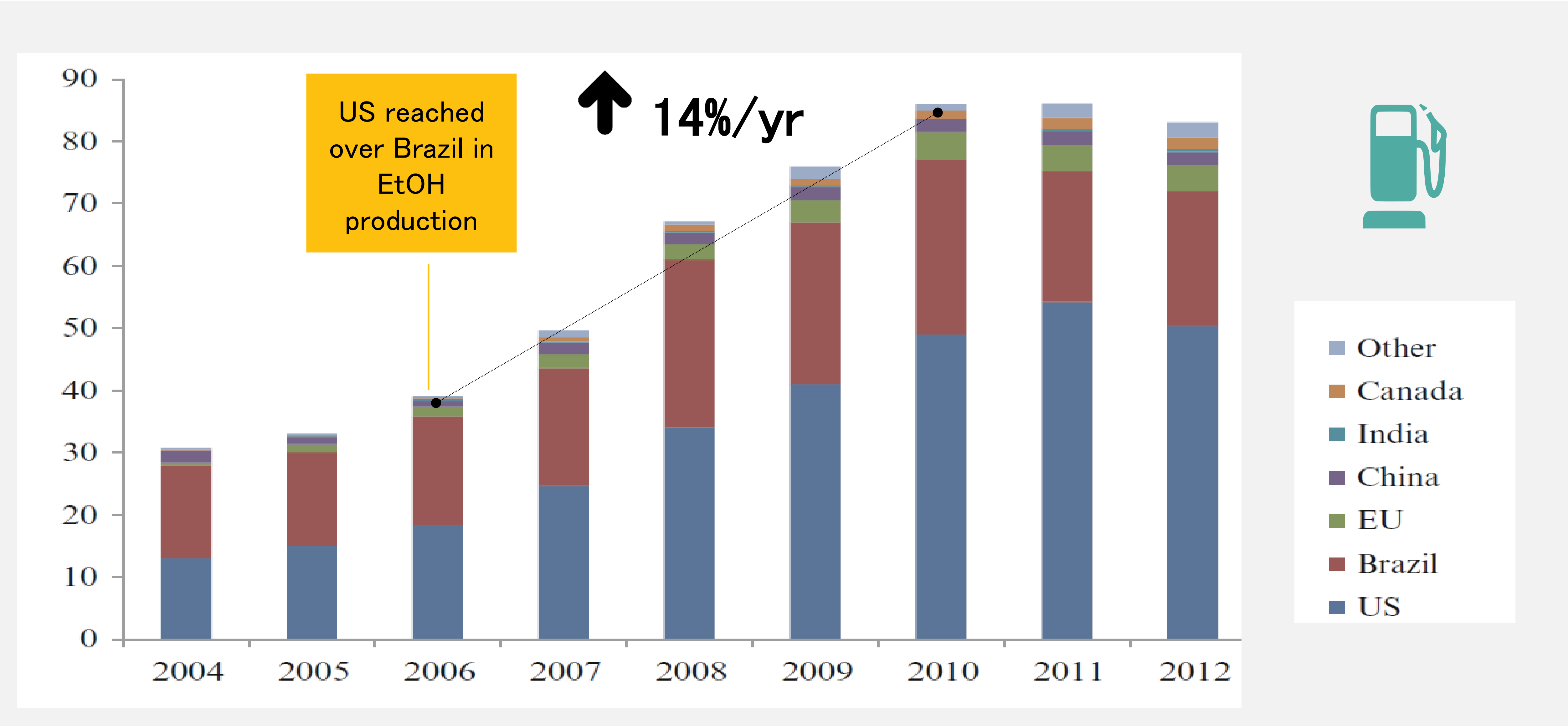
Biofuels Status today

Global fuel production



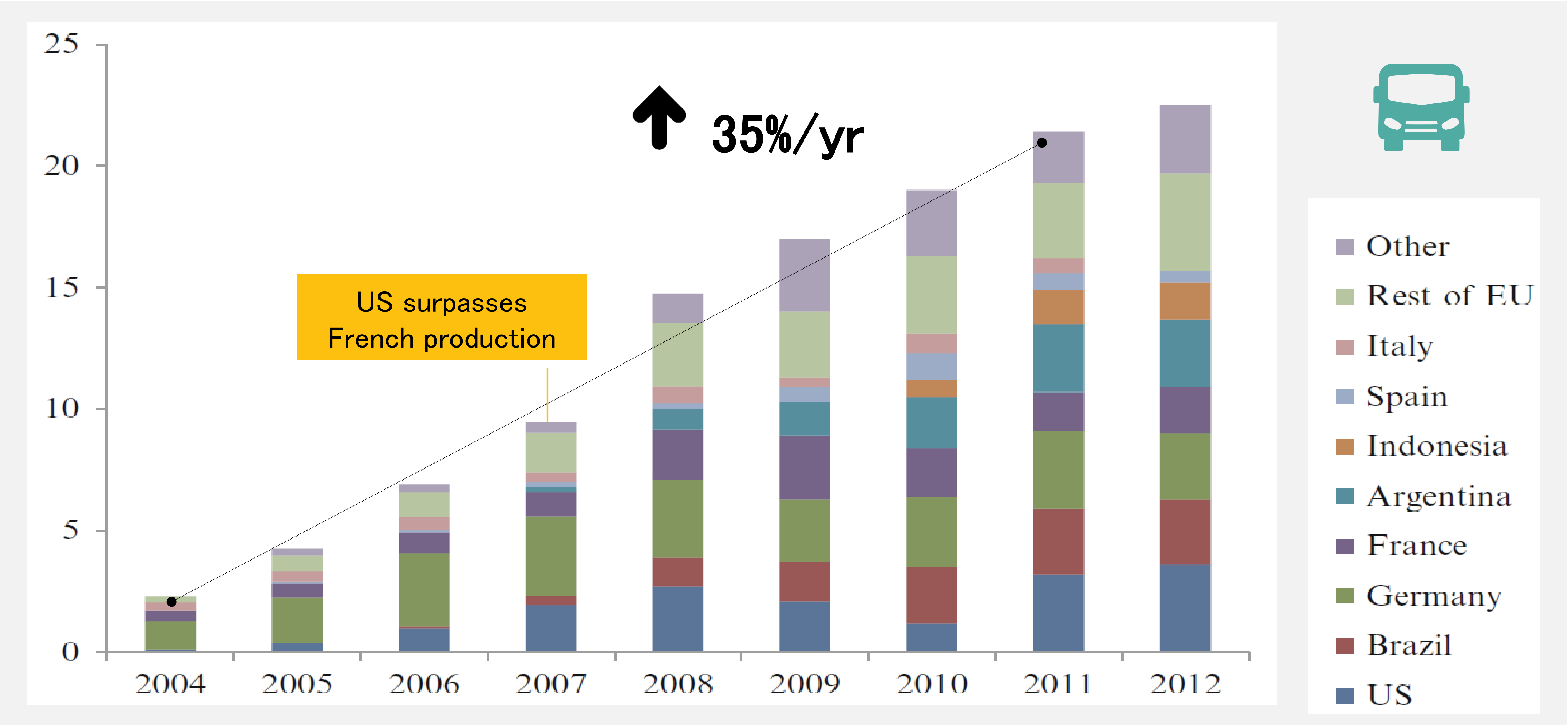
Source: IEA/OECD 2011
(Technology roadmap, Biofuels for Transport)

World largest ethanol producers



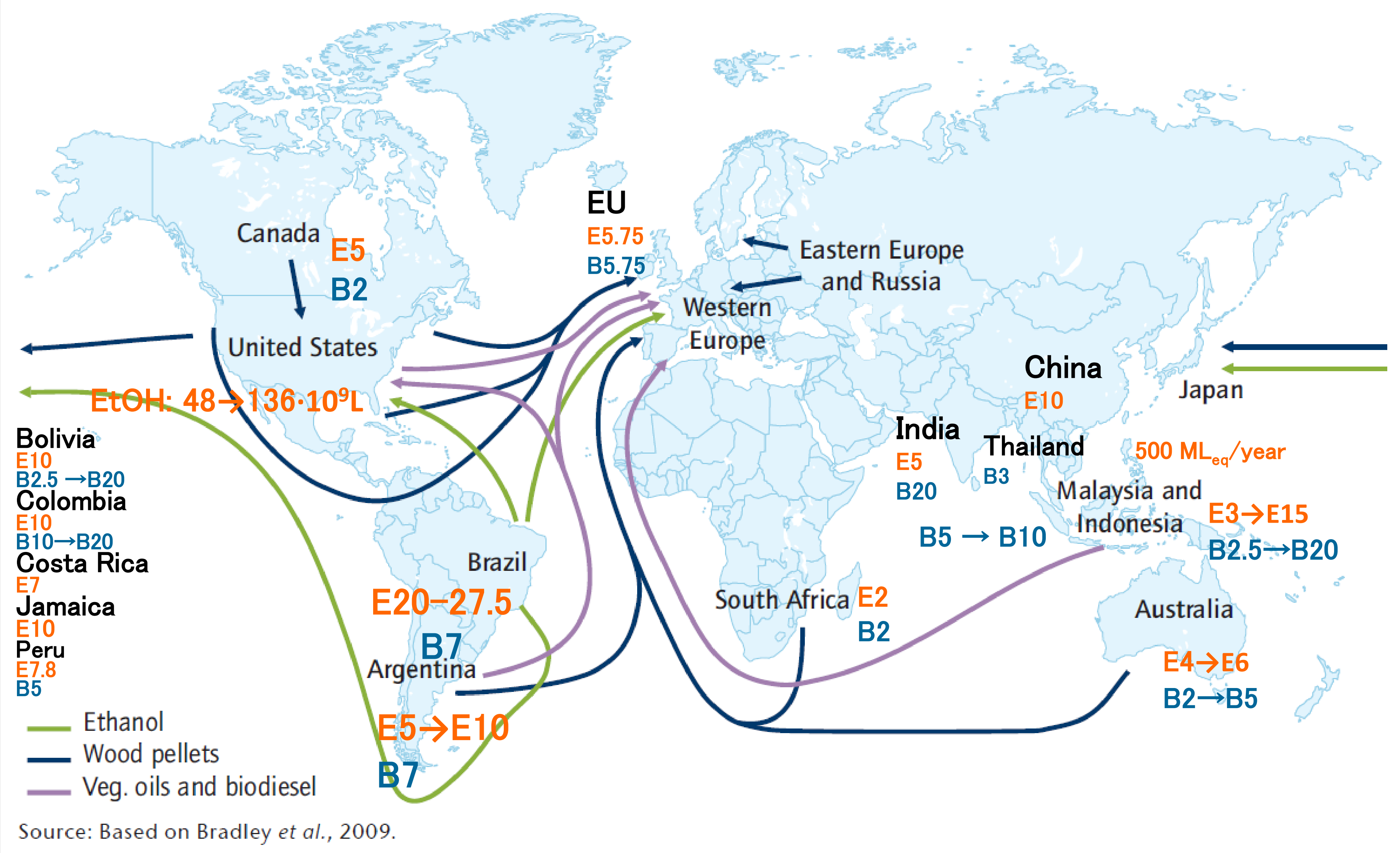
Source: Timilsina and Zibelman 2014

World largest biodiesel producers



Source: Timilsina and Zibelman 2014

World biomass trading & blends



Source: Based on IEA/OECD 2011 & USDA biofuel reports

World biomass trading & blends

Ethanol and biodiesel import/export balance

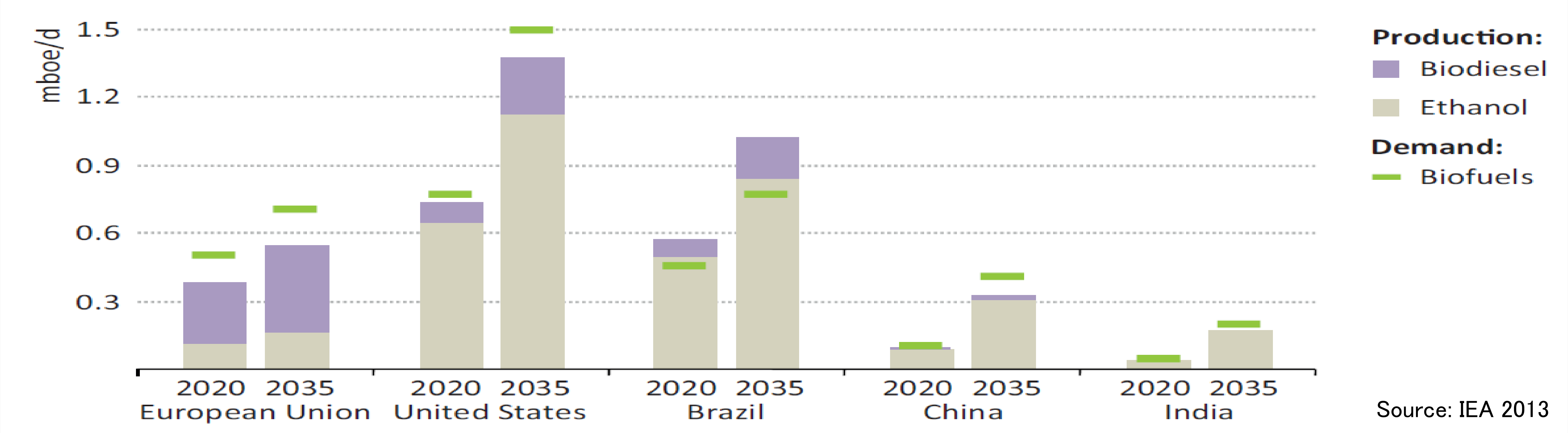
USA and EU are major importers

Fuel Ethanol			Biodiesel		
Exporter	Importer	Volume	Exporter	Importer	Volume
Brazil	US	325	Argentina	EU-27	1,611
Canada	US	36	Canada	US	103
El Salvador	US	46	EU-27	EU-27	4,812
Jamaica	US	109	EU-27	Norway	34
Trinidad & Tobago	US	225	EU-27	US	40
Brazil	EU-27	49	Indonesia	EU-27	1,225
Egypt	EU-27	28	Norway	EU-27	96
Guatemala	EU-27	17	US	EU-27	133
Pakistan	EU-27	23	US	Norway	26
Peru	EU-27	19	US	Canada	10
Russia	EU-27	12	US	Taiwan	28
US	EU-27	18	US	Israel	10
US	Brazil	1,500	US	Malaysia	8
EU-27	EU-27	1,572	US	Australia	6
			US	India	50

EU is a major importer

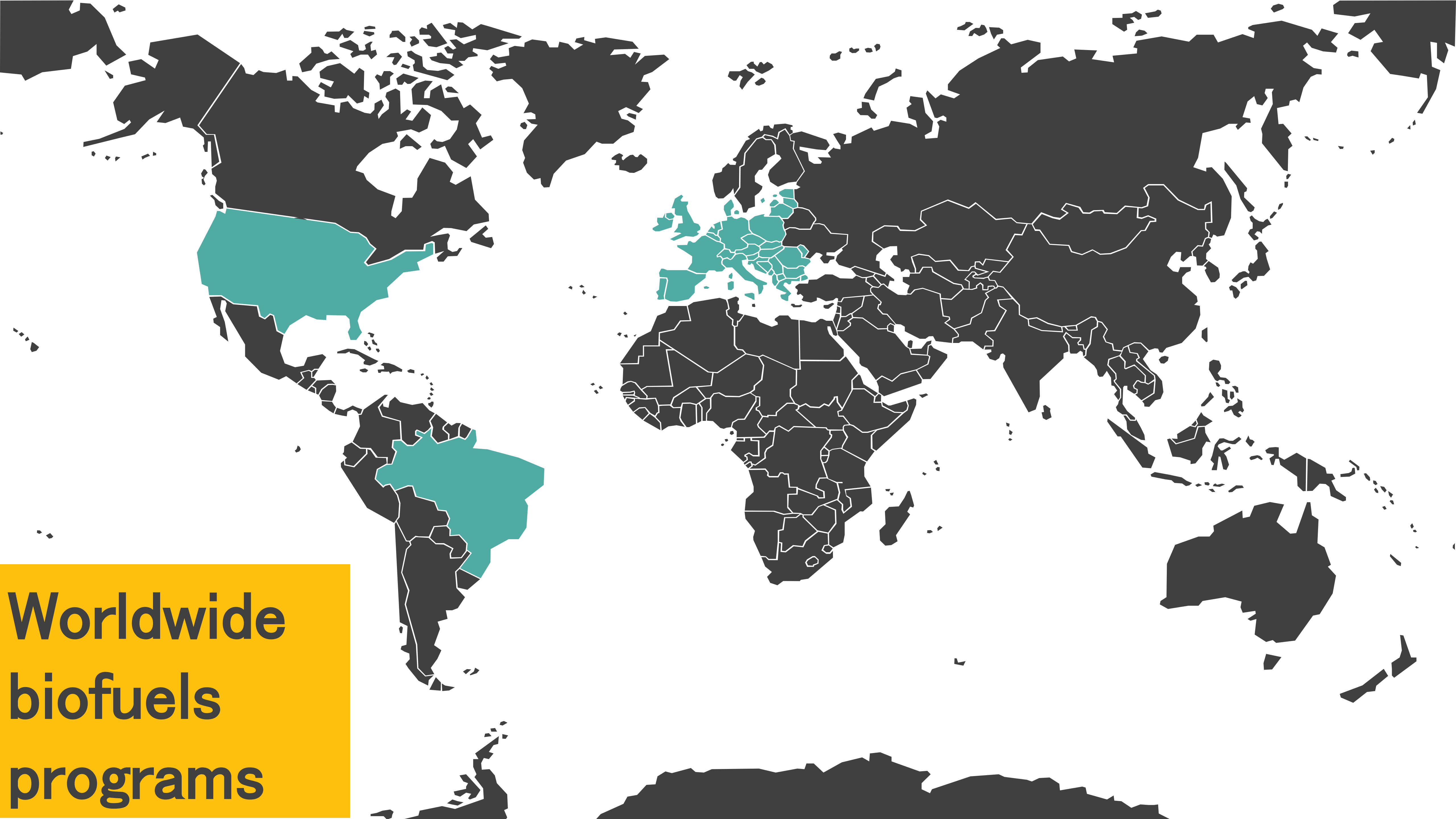
Source: Timilsina and Zibelman 2014

Future perspectives



- Biofuel consumption: ↑ from 1.3 to 4.1 mboe/d in 2035 → 8% of road-transport fuel demand in 2035
- US, Brazil, EU and China: ≥ 80% of all demand
- Brazil is the only large consumer able to meet its demand
- Advanced biofuels: 20% of biofuels supply in 2035

Worldwide biofuels programs

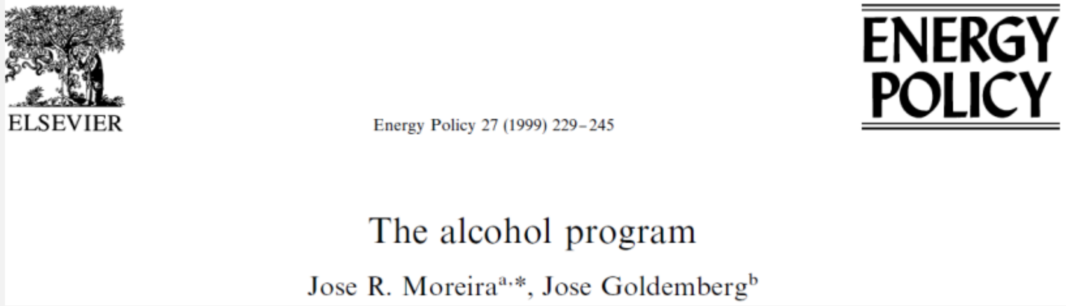


Brazil: Pro-alcohol program

Brazil: Pro-alcohol program

Drivers:

- Increasing oil prices (in the aftermath of the 1st oil crisis)
- Need to reduce trade balance deficit
- Need to control inflation
- Need to reduce dependence on imported fossil fuels
- Guarantee fuel security of supply
- Fuel to private vehicle mobility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Energy Policy 27 (1999) 229–245

ENERGY POLICY

The alcohol program

Jose R. Moreira[a,*], Jose Goldemberg[b]

Source: IEA 2013

Brazil: Pro-alcohol program

Phase I

1975 1979

Goal

increase production of anhydrous ethanol from 580,000 to 3 bil L by 1980 (~E20)

- Creation of the National Executive Commission for Alcohol(CENAL) to manage the program
- Incentives to implement attached distilleries to existing sugar mill units

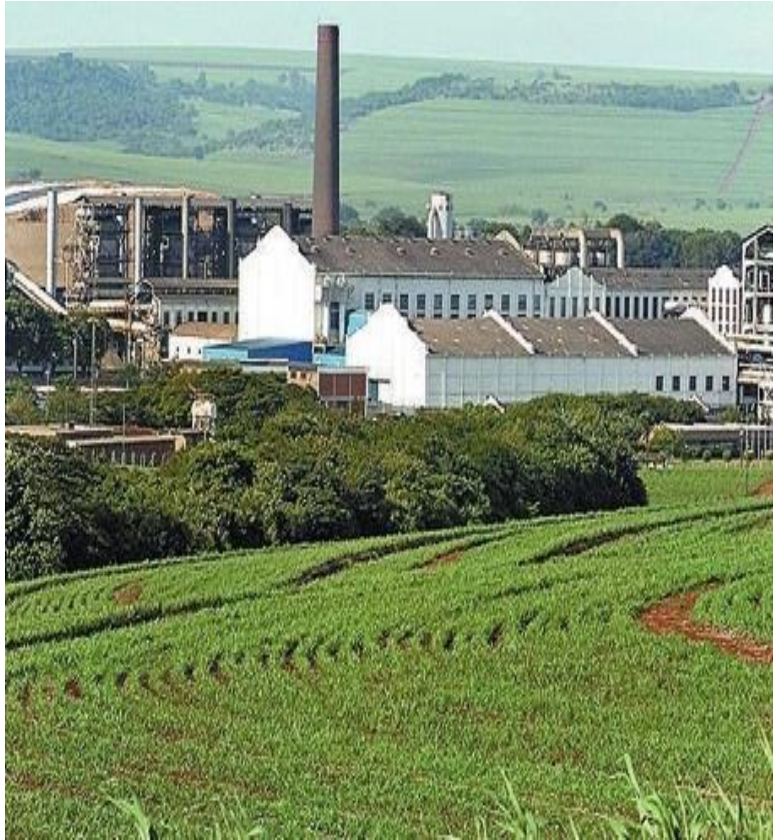
(Nogueira 2008)

Brazil: Pro-alcohol program

Phase II

1975 | 1979 | 1980 | 1985

- Reinforcement of phase I
- Creation of the Conselho Nacional do Álcool (CNAL)
- Incentives to purchase dedicated hydrated ethanol vehicles (new E100 veh sales increased from <1 to 76%)
- Establishing higher target of ethanol blends in gasoline (progressively increased to 25%)
- Regulated price of hydrated ethanol to make it competitive with gasoline
- Guarantying competitive prices to ethanol producers, even if international sugar prices were more attractive



Brazil: Pro-alcohol program

Phase II

1975 1979 1980 1985

Brazil: Pro-alcohol program

Phase III

1975 | 1979 | 1980 | 1985 | 1986 | 1995

- Fall of crude oil prices (US$12-20) and strengthening of sugar prices
- Reduction of incentives to ethanol producers
- Supply ≠ Demand
- Ethanol shortage → substitution of pure ethanol by a mixture of 60% EtOH, 34% methanol and 6% gasoline
- Lost of consumers' trust
- Sharp reduction of E100 veh sales

Brazil: Pro-alcohol program

Phase IV

1975 1979 1980 1985 1986 1995 1996 2003

- Phase out of ethanol subsidies
- Free market of anhydrous and hydrated ethanol between producers and distributors
- Creation of the National Energy Policy Council (CNPE) (planning) and the National Agency for Petroleum, Natural
- Gas and Biofuels (ANP) (regulation, contracting, and inspection)

Brazil: Pro-alcohol program

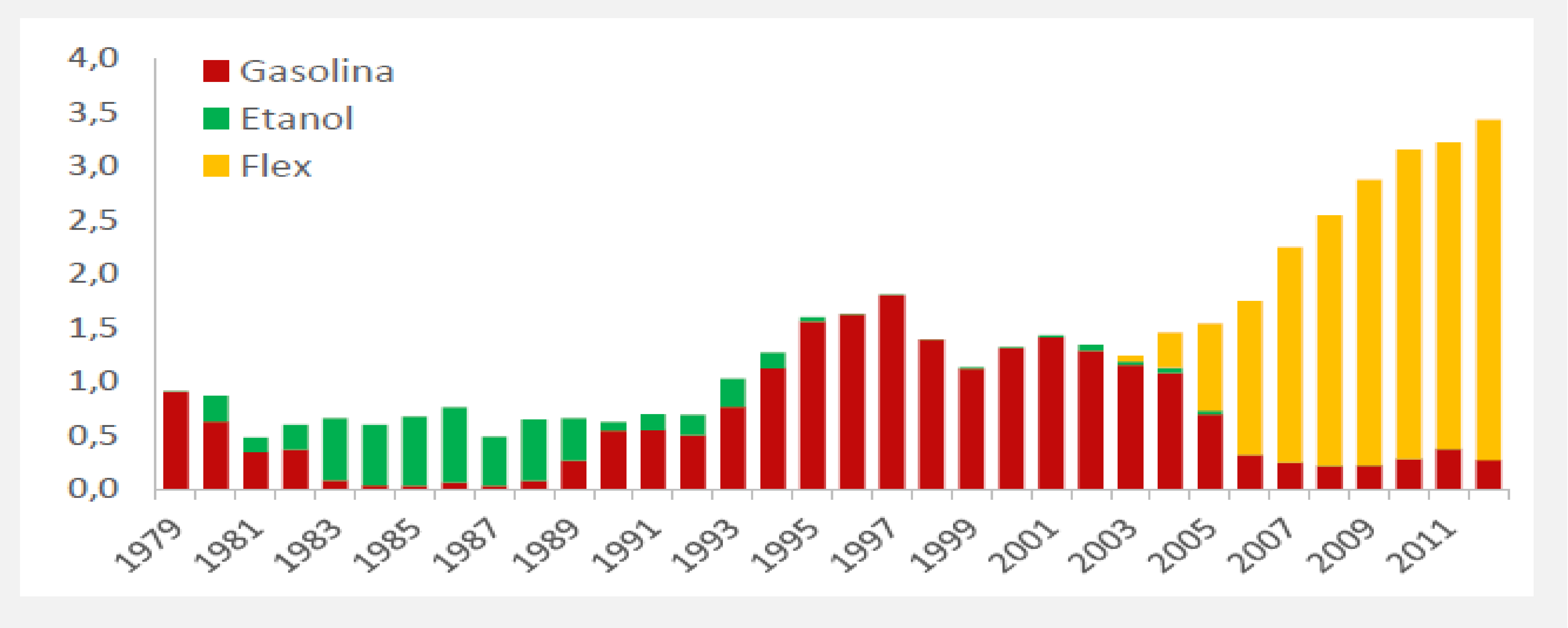
Phase V

1975 | 1979 | 1980 | 1985 | 1986 | 1995 | 1996 | 2003 | ?

- Introduction of Flexible Fuel Vehicles (FFV) (89% share in new vehicle sales) (ANFAVEA 2014)
- Dominance of light passenger vehicle market (as in 2013 ~3.2 mil FFV)
- Phase out of E100 vehicles

Brazil: Pro-alcohol program

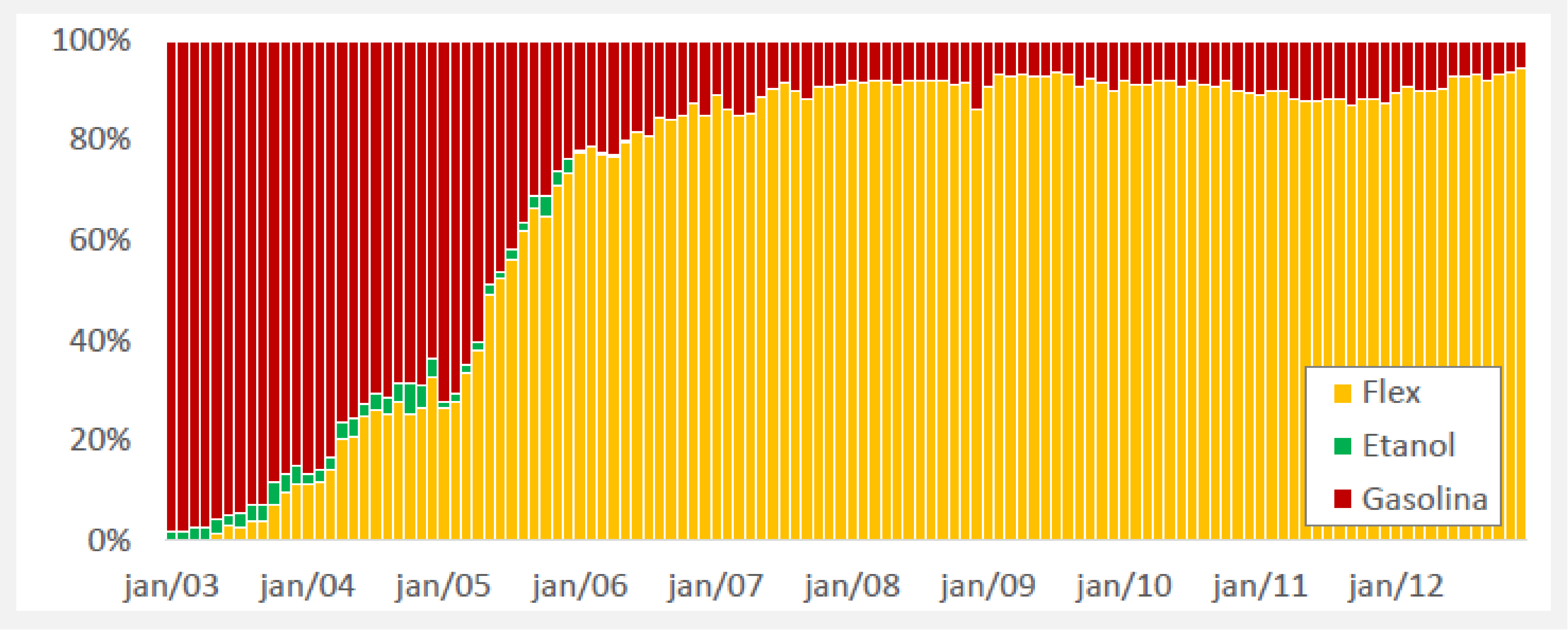
LDV sales in Brazil (in million vehicles per year) (ANFAVEA, 2014)



Source: IEA 2013

Brazil: Pro-alcohol program

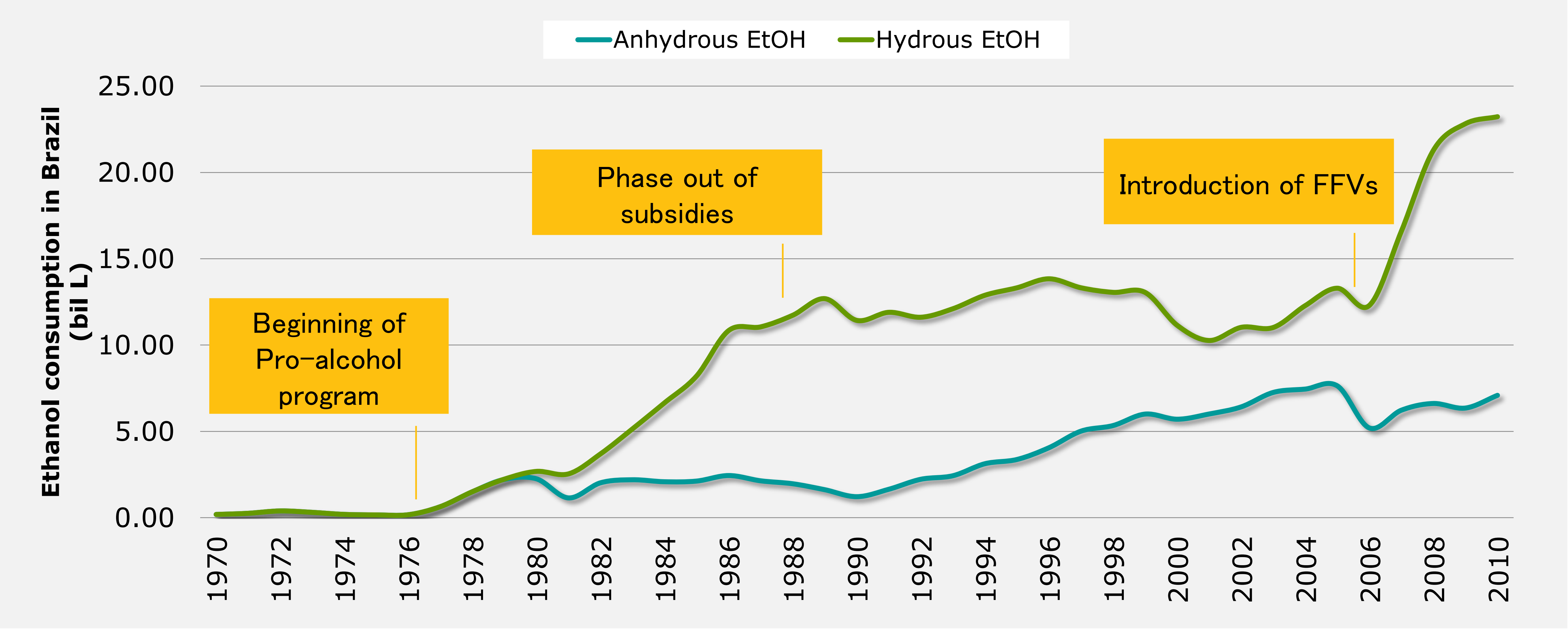
Evolution of LDV flexfuel sales in Brazil (in % per year) (MME, 2013)



Source: IEA 2013

Brazil: Pro-alcohol program

Evolution of ethanol consumption



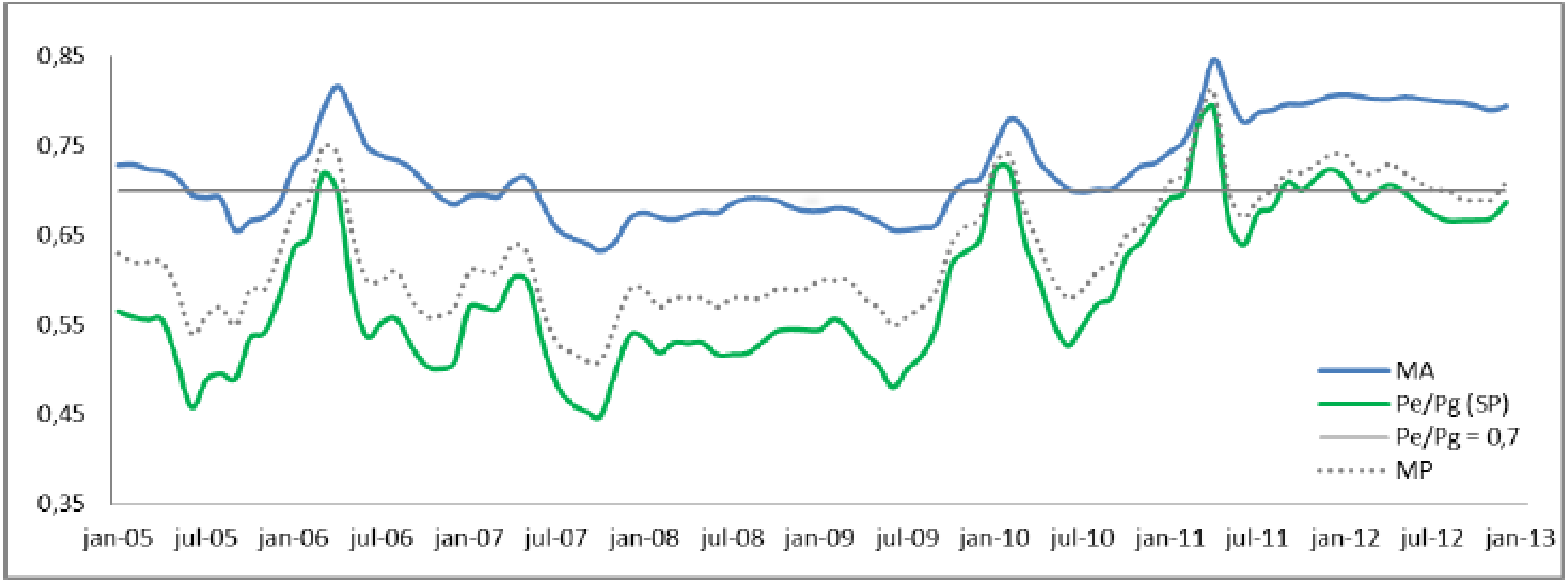
Sources: CONAB 2014; MAPA 2014

Recent trends

- Ethanol industry crisis
- Governmental subsidy to gasoline reduced ethanol producers' profits
- Extreme weather conditions in the last years → ↓ sugarcane yields
- Mechanisation harvest → high investment, ↓ sugar content in the stalks → ↓ productivity
- Farmers are not substituting stalks after the 6 year turn over period → ↓ sugarcane yields
- Between 2008 and 2014, 66 ethanol distilleries resumed activities (UNICA, 2014)

Brazil: Pro-alcohol program

Consumer prices of hydrated ethanol vs. gasoline per state in Brazil



Sources: CONAB 2014; MAPA 2014

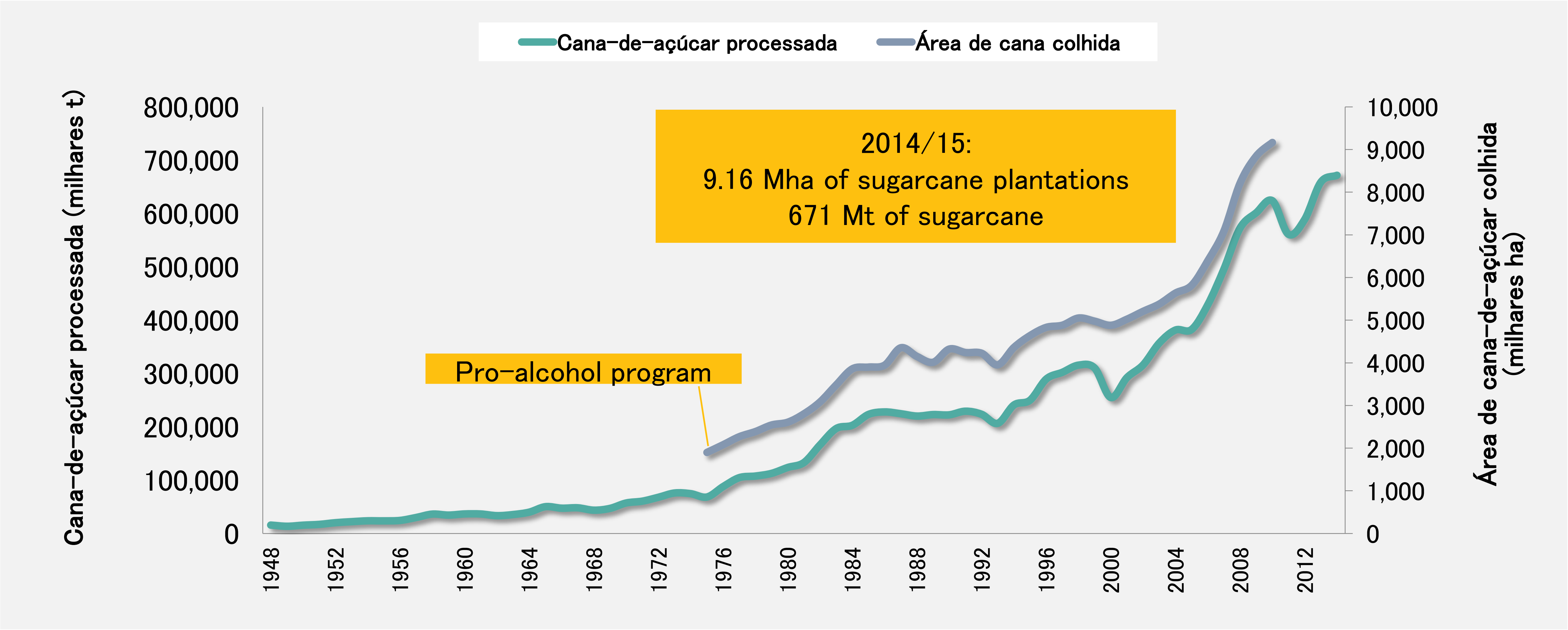
Brazil: Pro-alcohol program

Consumer prices of hydrated ethanol vs. gasoline in Brazil

Sources: CONAB 2014; MAPA 2014

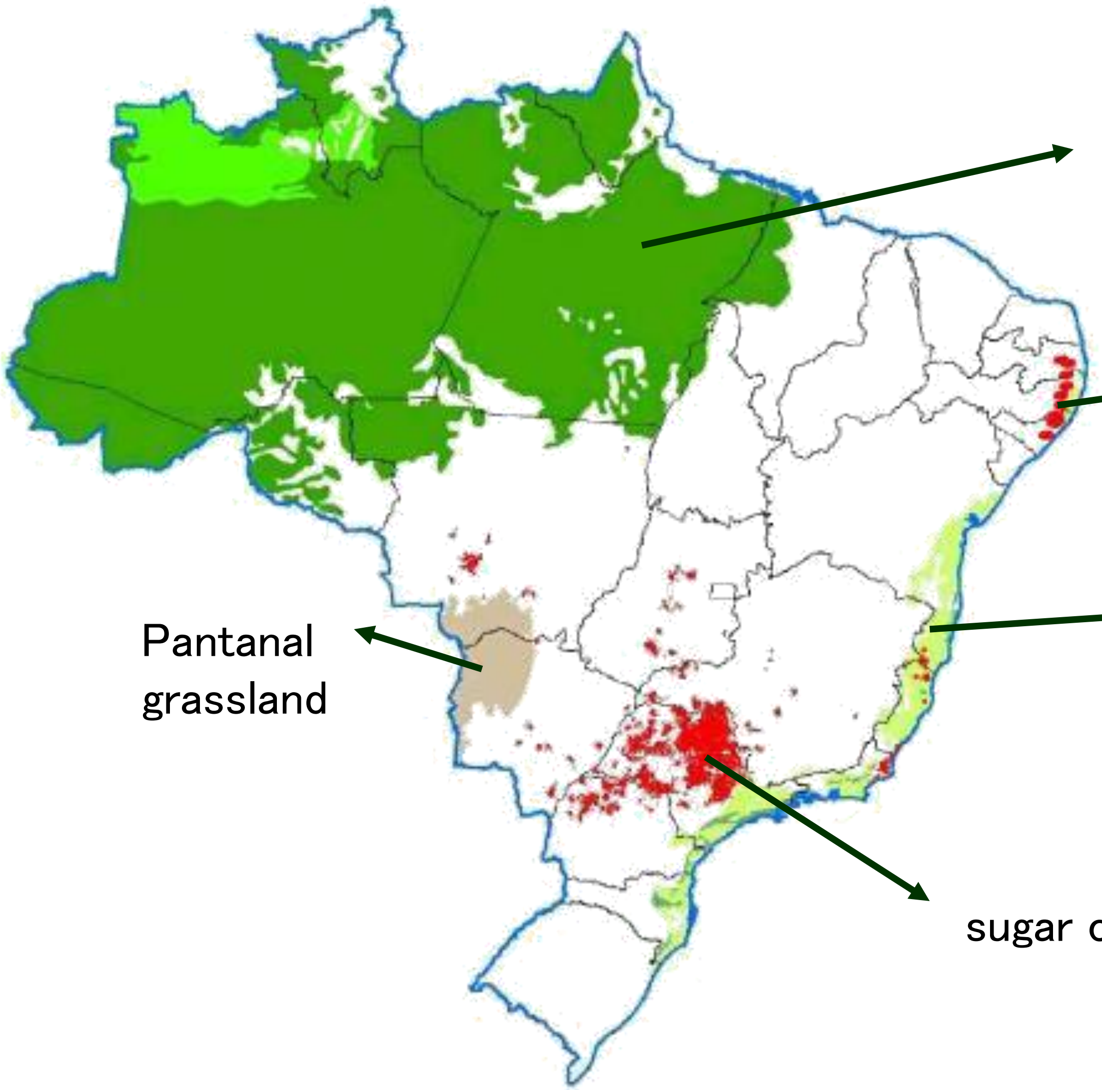
Brazil: sugarcane ethanol production

Evolution of ethanol consumption



Sources: CONAB 2014

Brazil: sugarcane ethanol production

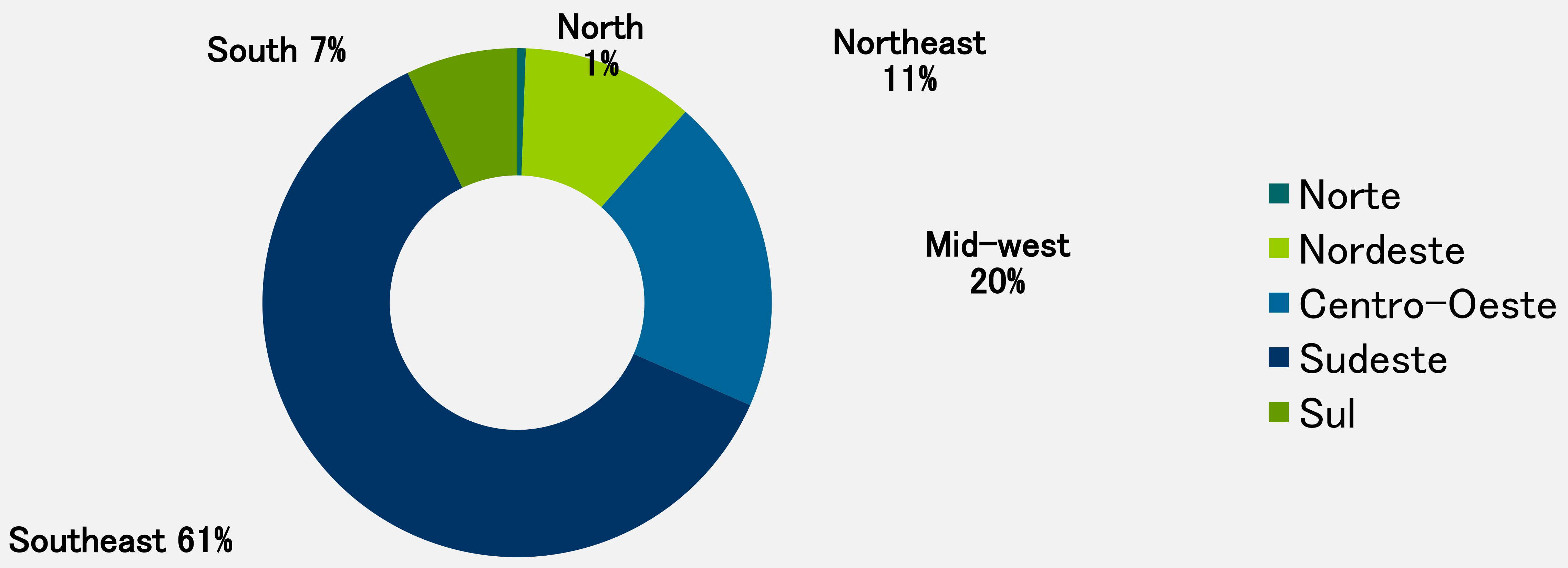


- Sugarcane cropland corresponds to less than 7% of total agricultural land in Brazil (9.16 Mha)
- 671 Mt of sugarcane
- 376 (as for 2014) ethanol producing units

Sources: Goldemberg 2008; CONAB 2014

Brazil: sugarcane ethanol production

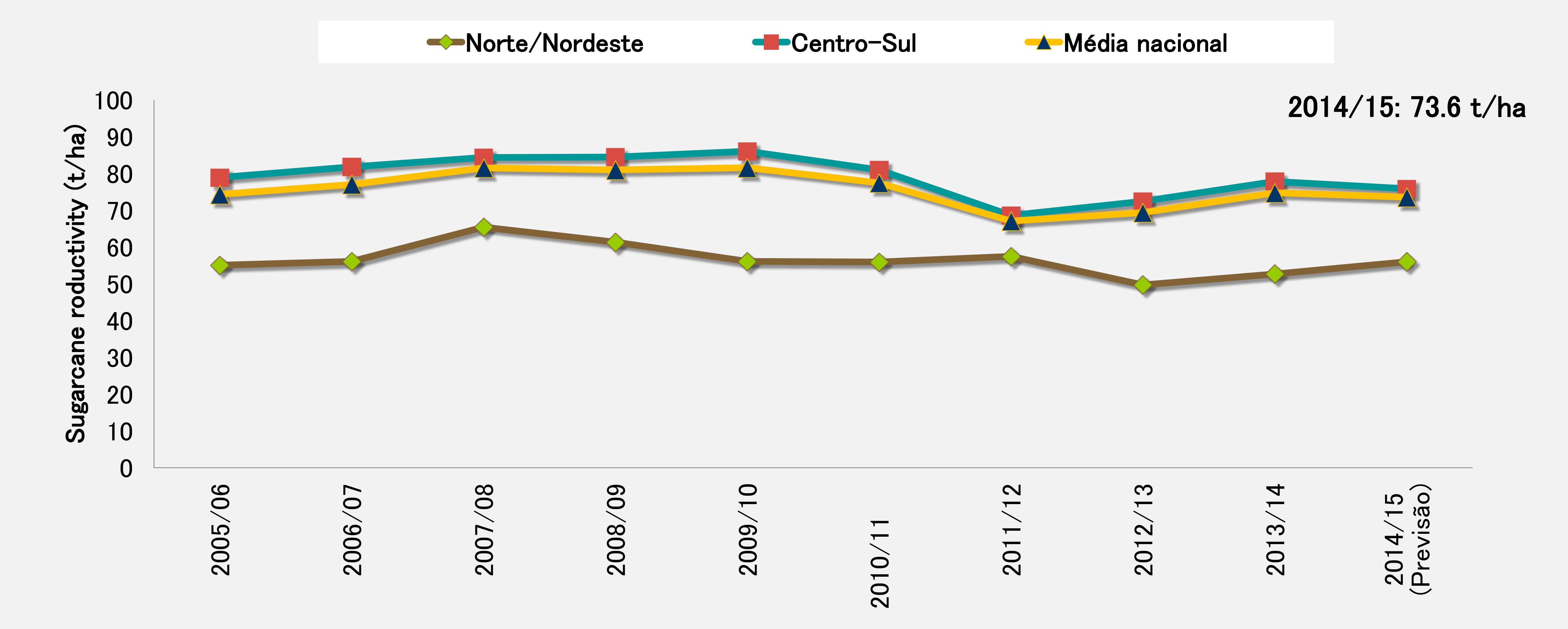
Share of sugarcane produced by region



Sources: CONAB 2014; MAPA 2014

Brazil: sugarcane ethanol production

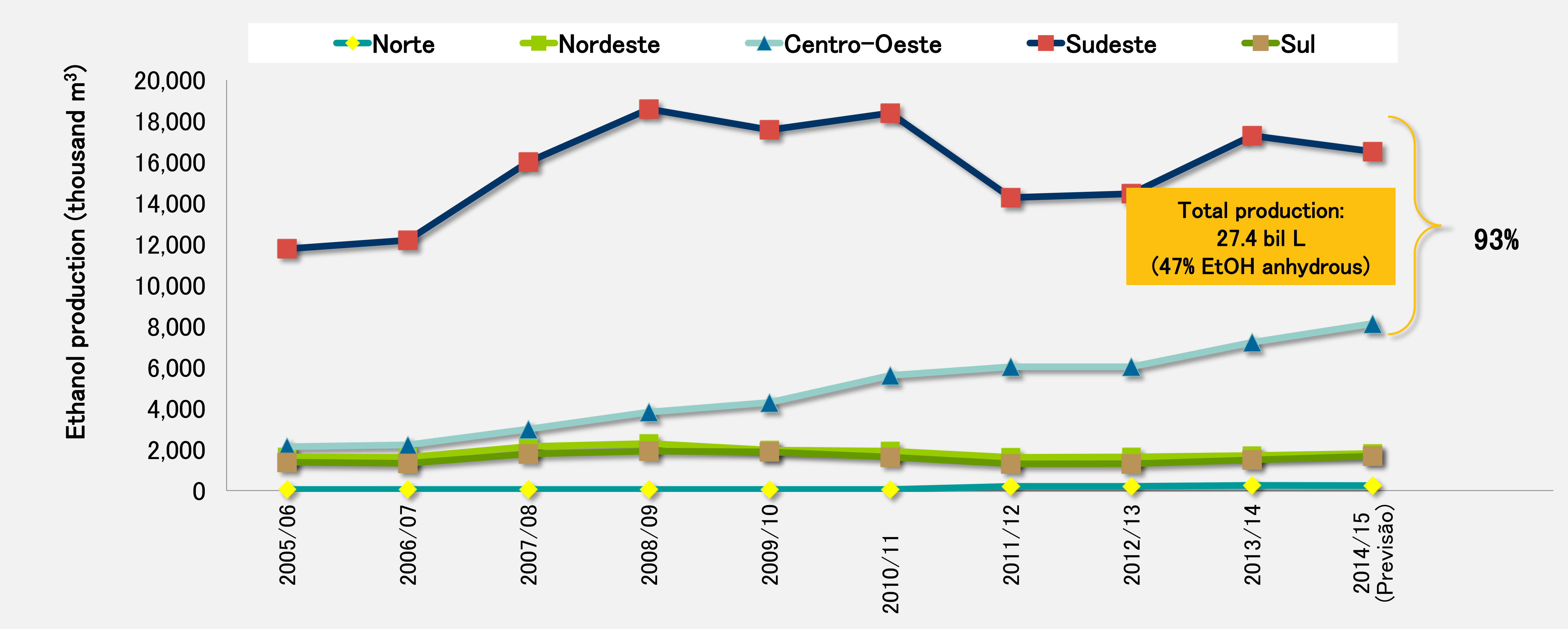
Average yields of sugarcane in Brazil



Sources: CONAB 2014; MAPA 2014

Brazil: sugarcane ethanol production

Ethanol production in different regions of Brazil



Sources: CONAB 2014; MAPA 2014

USA corn-to-ethanol program

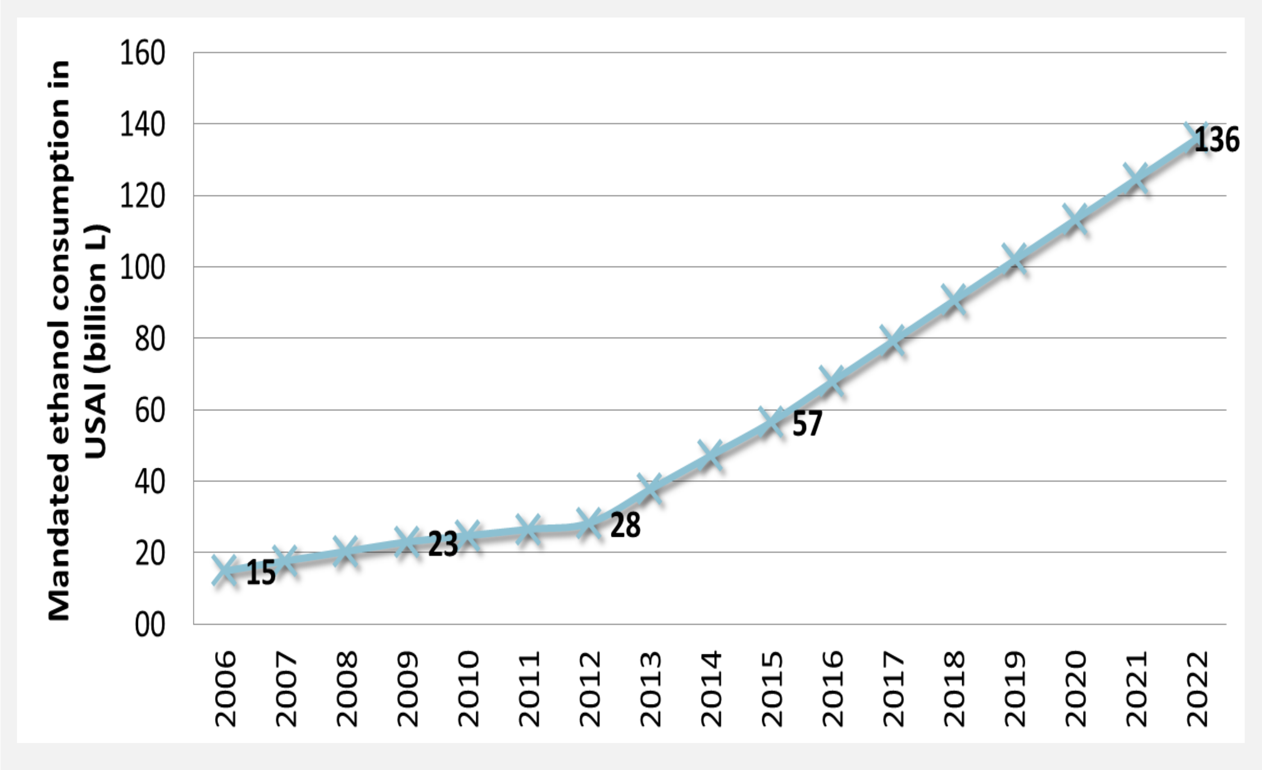
USA corn-to-ethanol program

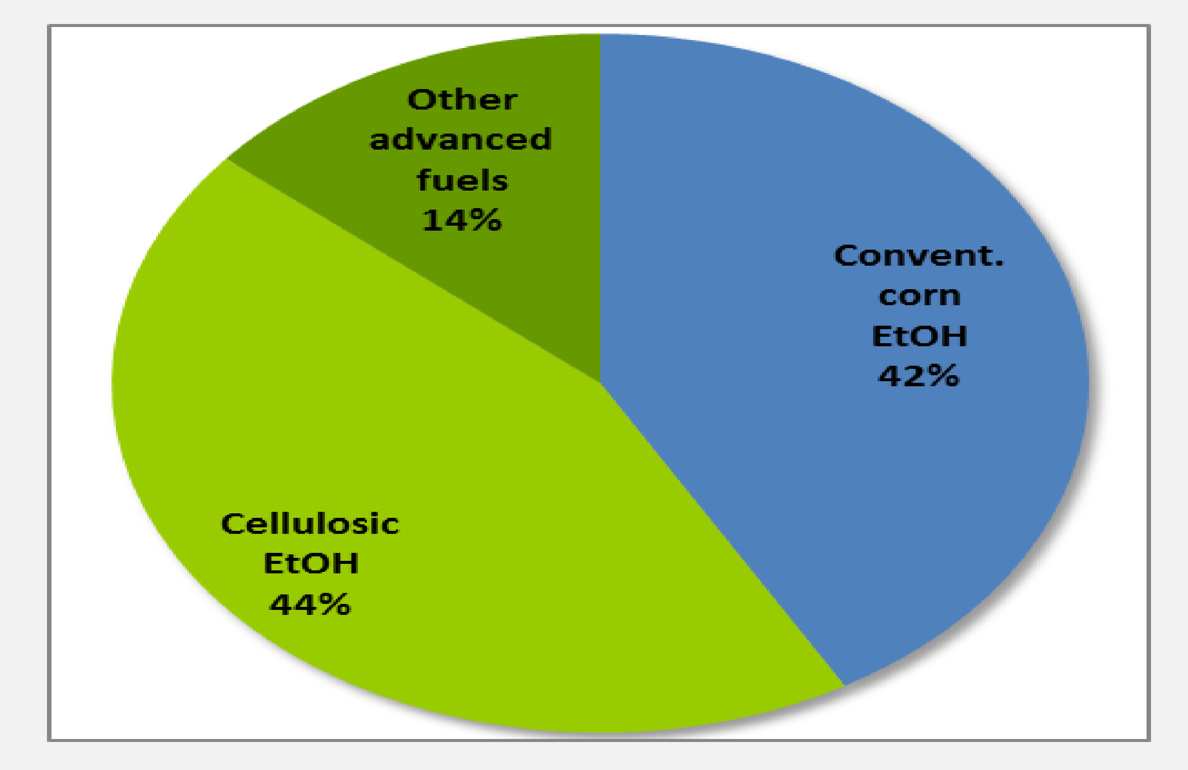
Drivers:

- Reduce dependence on imported fossil fuels
- Enhance energy security of supply
- Diversify fuel production mix
- Support the agricultural sector

USA corn-to-ethanol program

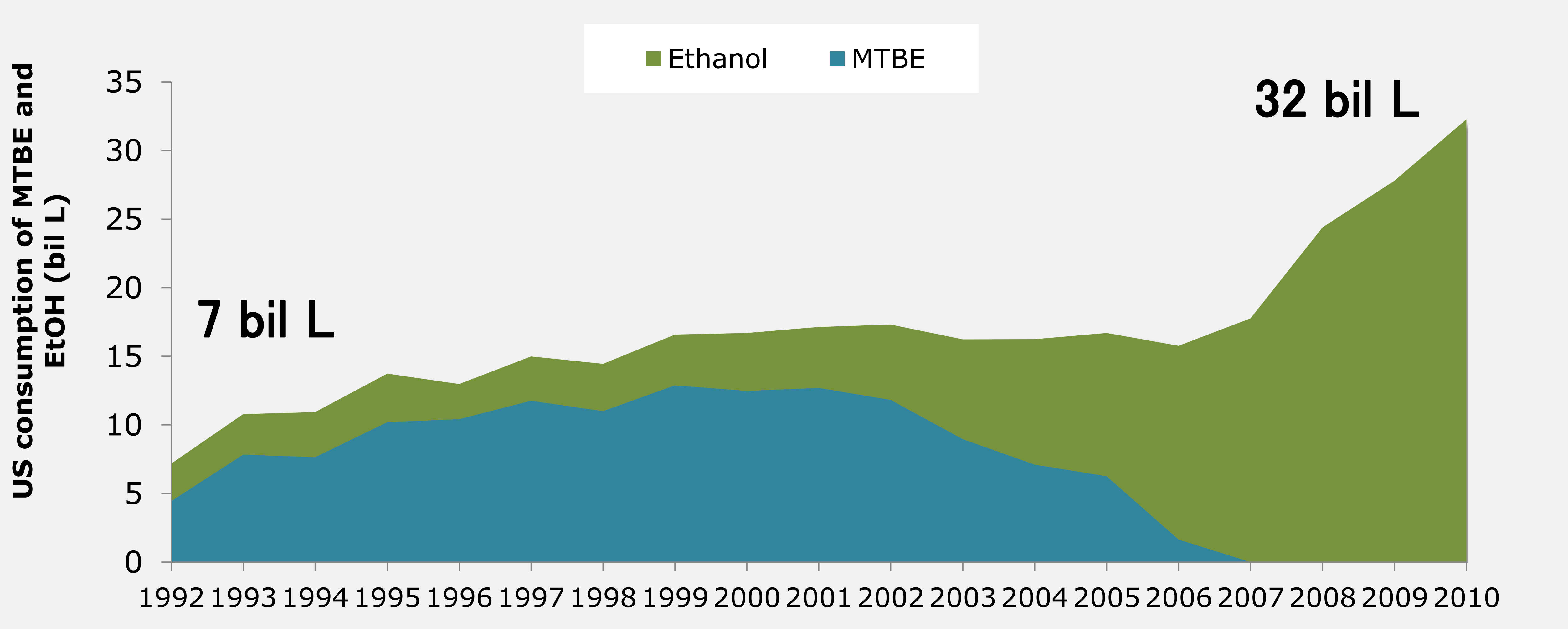
Energy Independence and Security Act (EISA) 2005 and 2007 mandate the use of biofuels in US's transportation sector (E10, E15, E85, E-diesel)



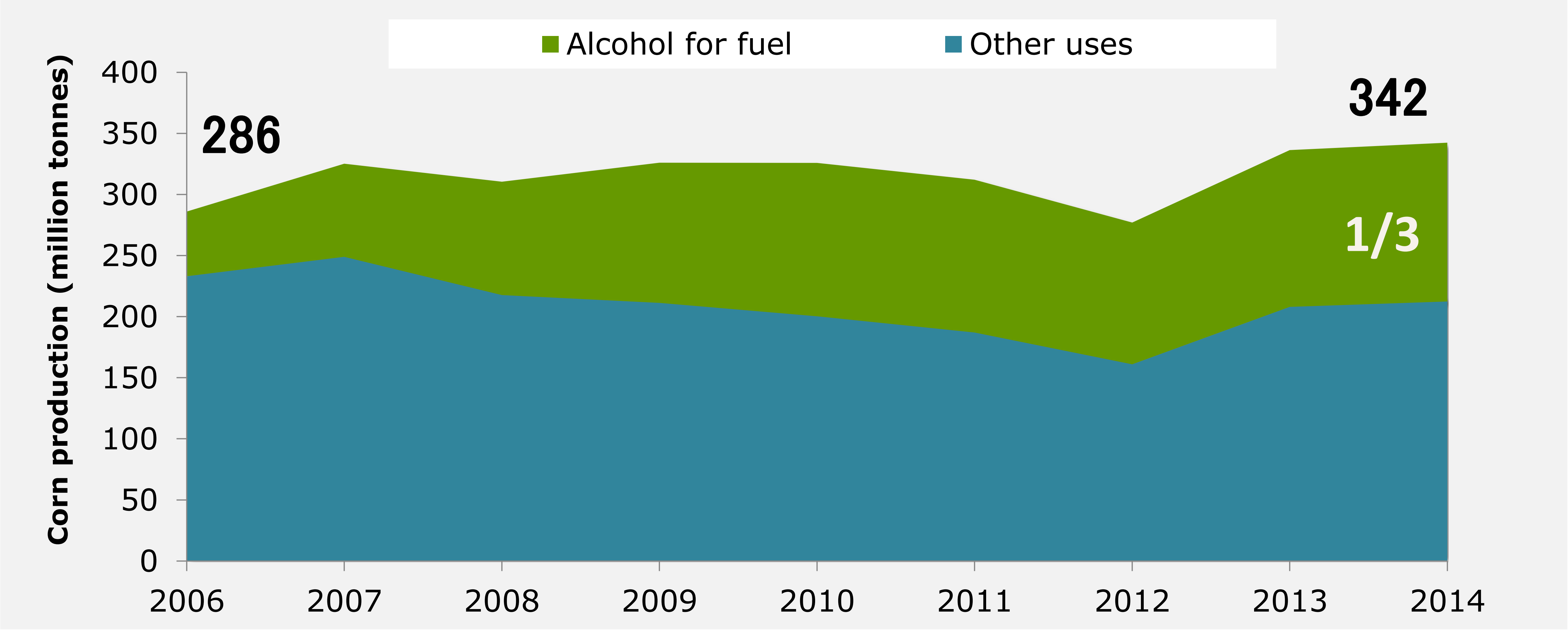


USA corn-to-ethanol program

US consumption of MTBE and ethanol in gasohol



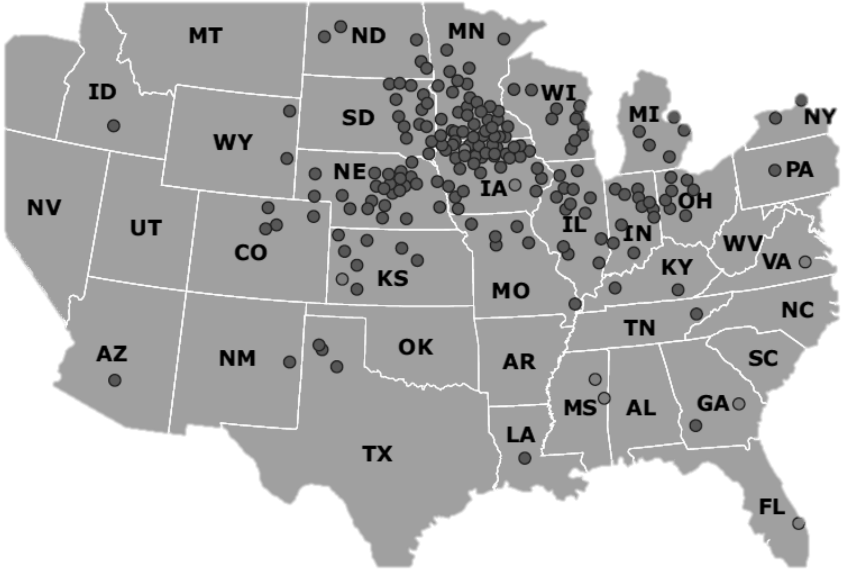
USA corn-to-ethanol program



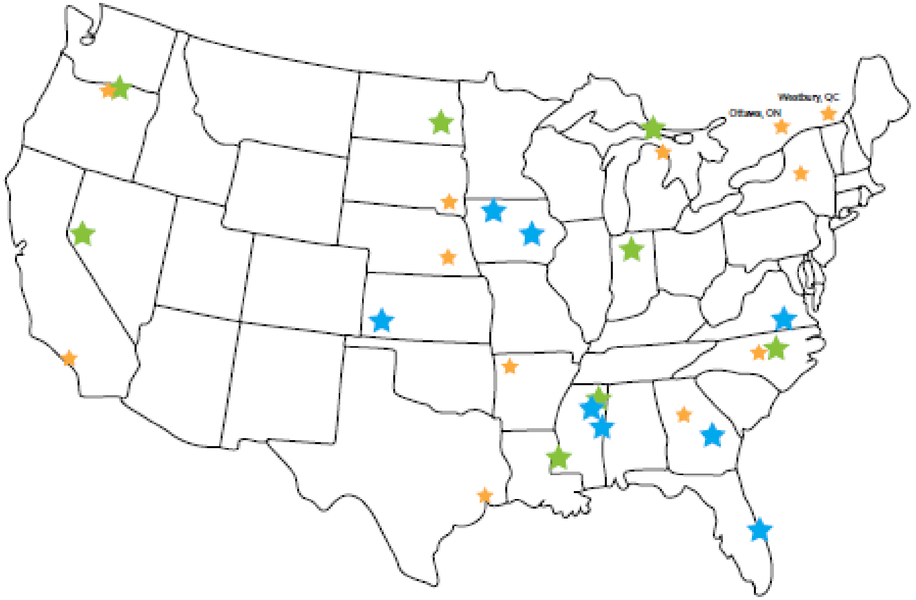
USA corn-to-ethanol program

Biorefineries in the US (2013)

- 198 in operation (installed capacity 57.5 bil L/yr)
- Ethanol substitutes about 10% of gasoline supply



Conventional biorefineries

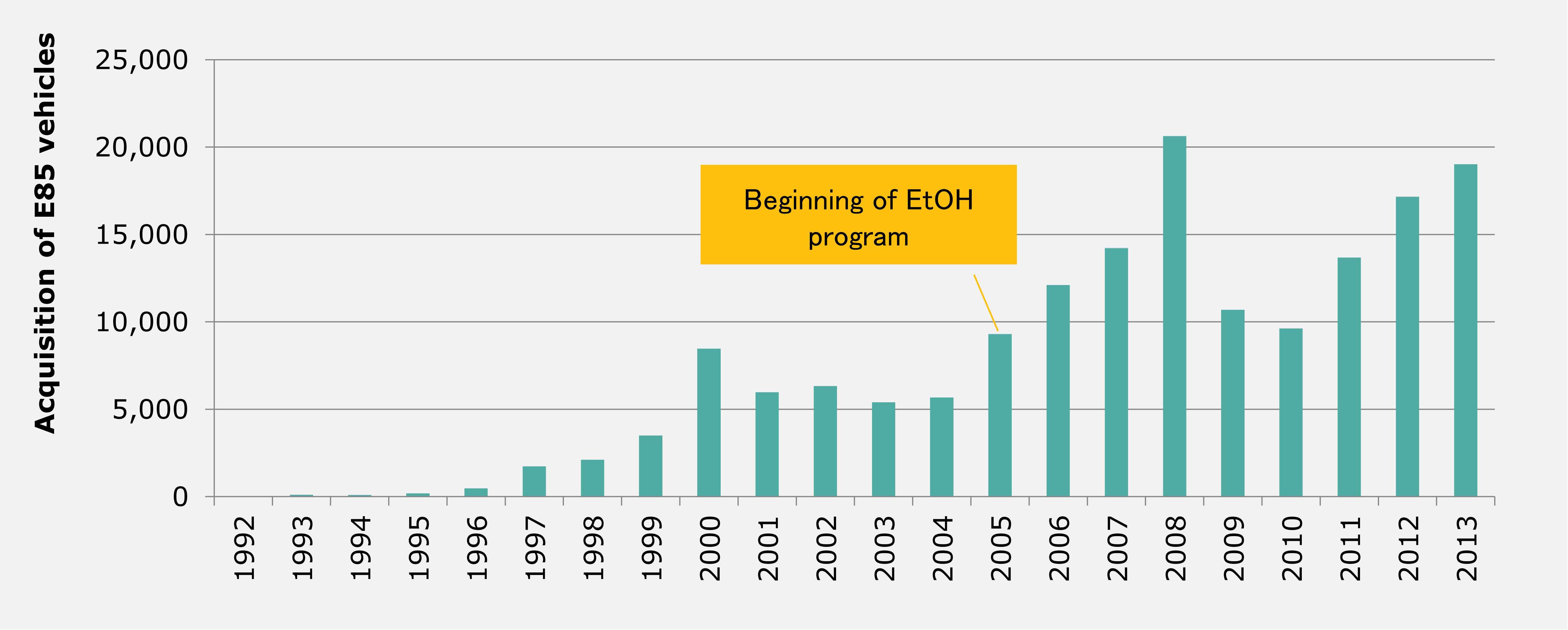


Cellulosic ethanol biorefineries

Source: RFA 2015

USA corn-to-ethanol program

E85 light passenger vehicle fleet

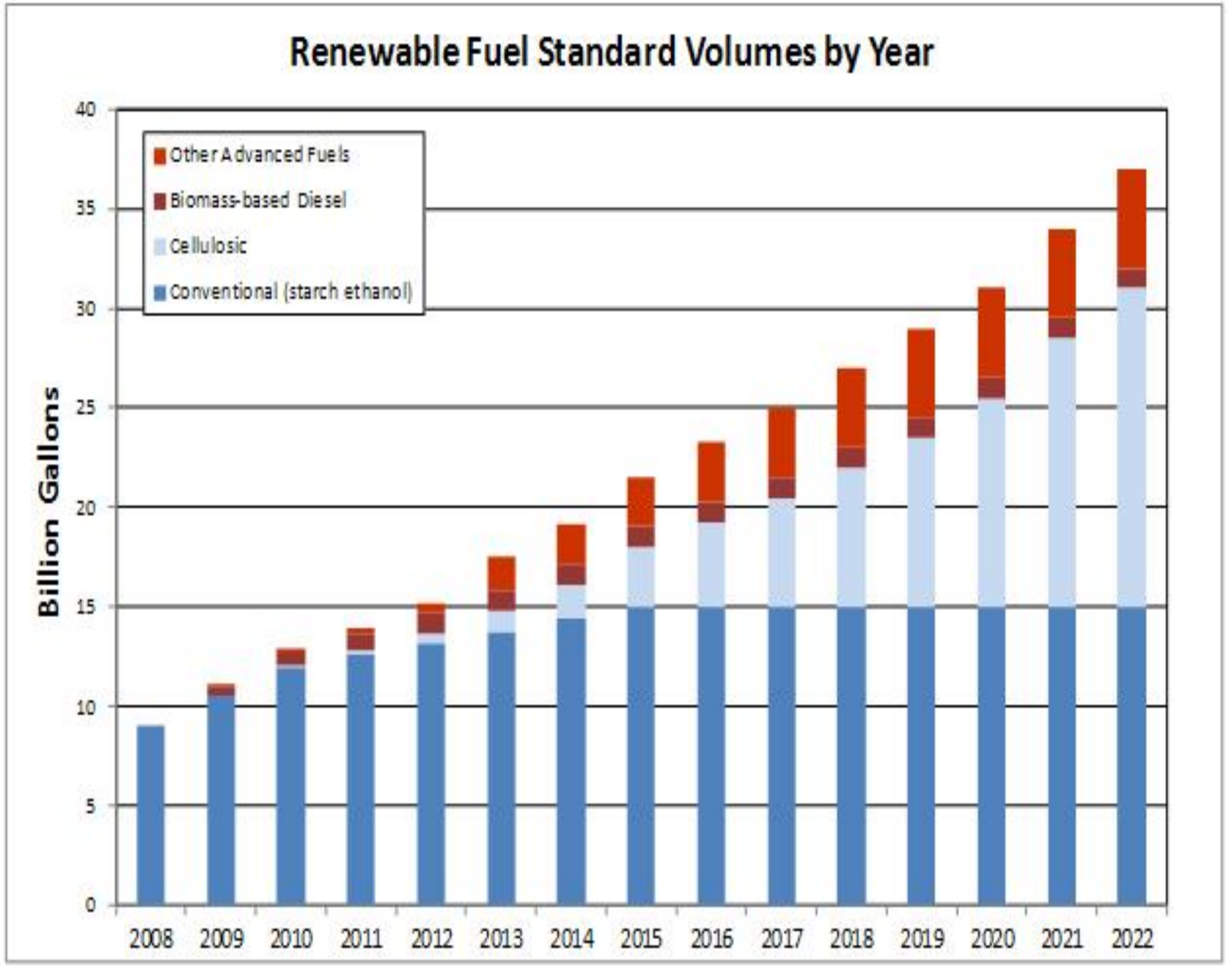


Source: RFA 2015

USA corn-to-ethanol program

More recent trends

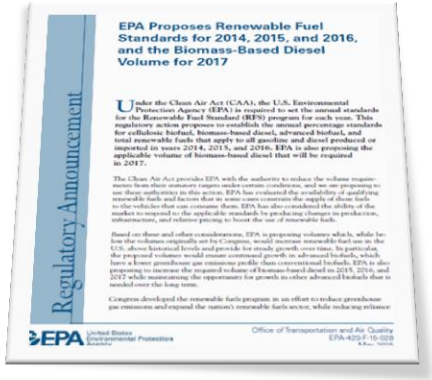
- EPA requires that the Renewable fuel standard program includes specified volumes of renewable fuels according to the categories:
  - **Conventional biofuel**: Starch ethanol (e.g., corn and grain sorghum). Plants built after 2007 must demonstrate ↓ **20%** LCA-GHG emissions
  - **Advanced Biofuel**: fuels from cellulosic or advanced feedstocks (including sugarcane). ↓ **50-60% LCA-GHG emissions**



Sources: EPA 2015

USA corn-to-ethanol program

- More recent trends
  - EPA tried to lower the unrealistic progress targets for corn and advanced ethanol (2014)
  - EPA's proposal could cut RFS target for advanced biofuels by 20%
    - "**Limitations** in **the volume of ethanol** that can be consumed given practical constraints on the supply of higher ethanol blends to the vehicles that can use them"
    - "**Limitations** in the **ability of the industry to produce sufficient volumes of qualifying renewable fuel**, particularly non-ethanol fuels"


Regulatory Announcement

EPA Proposes Renewable Fuel Standards for 2014, 2015, and 2016, and the Biomass-Based Diesel Volume for 2017

Proposed Percentage Standards

	2014	2015	2016
Cellulosic biofuel	0.019%	0.059%	0.114%
Biomass-based diesel	1.42%	1.41%	1.49%
Advanced biofuel	1.52%	1.61%	1.88%
Total renewable fuels	9.02%	9.04%	9.63%

Sources: EPA 2015

USA corn-to-ethanol program

	Brazil	USA
Start of the program	1970’s	Early 2000’s
Feedstock	Sugarcane	Corn
Ethanol production (2013) (bil L/yr)	27	50
Total area used for ethanol crop (2006) (mil ha) (% arable A_t)	3.6 (1%)	10 (3.7%)
Number of dedicated processing units	211	376
Ethanol yield (L/ha)	6,800 – 8,000	3,800 – 4,000
Energy balance (NEV)	8.3 – 10.2	1.3 – 1.6
GHG emission reduction	86–90%	10–30%
Number of ethanol fuelling stations	35,017 (100%)	2,749 (1.6%)
Ethanol’s share within the gasoline market	~50%	10%
Cost of production (USD/L)	0.21	0.30

USA corn-to-ethanol program

Criticisms:

- Strongly based on fiscal incentives (cumulative subsidies between 2005 and 2007: US$17 bil, 2015: US$54 bil)
- Corn ethanol might have negative impacts on food security and water footprint
- Most distilleries are heavily dependent on fossil fuels

Rev Environ Contam Toxicol 189:25–41 © Springer 2007

Ethanol Production: Energy, Economic, and Environmental Losses

David Pimentel, Tad Patzek, and Gerald Cecil

Ethanol Production Using Corn, Switchgrass, and Wood; Biodiesel Production Using Soybean and Sunflower

David Pimentel[1,3] and Tad W. Patzek[2]

Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land-Use Change

Timothy Searchinger,[1*] Ralph Heimlich,[2] R. A. Houghton,[3] Fengxia Dong,[4] Amani Elobeid,[4] Jacinto Fabiosa,[4] Simla Tokgoz,[4] Dermot Hayes,[4] Tun-Hsiang Yu[4]

European Union biofuels program

European Union biofuels programm

Drivers:

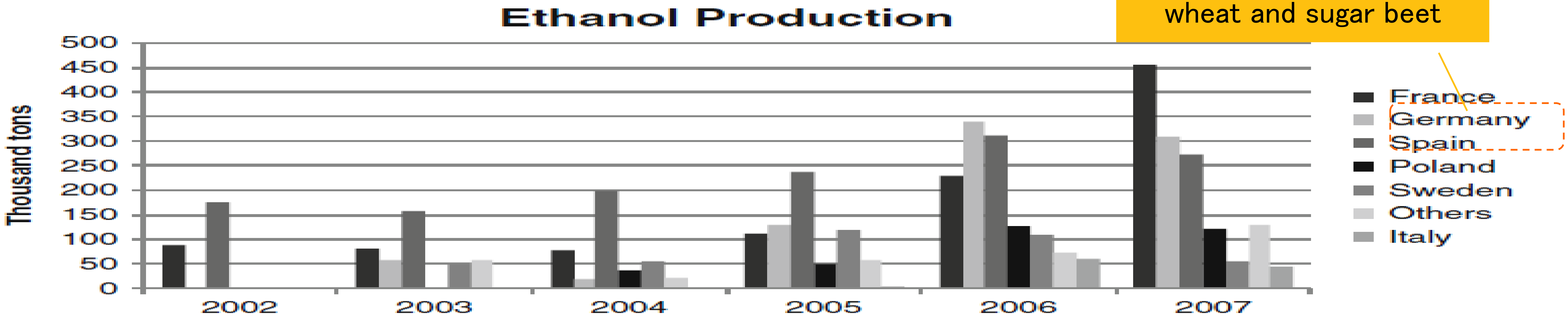
- Support agricultural sector of member states (mainly Germany, France and Spain)
- Reduce dependence on imported fossil fuels (80% of imported fossil fuels)
- Guarantee energy security of supply
- (Climate change mitigation)

European Union biofuels programm

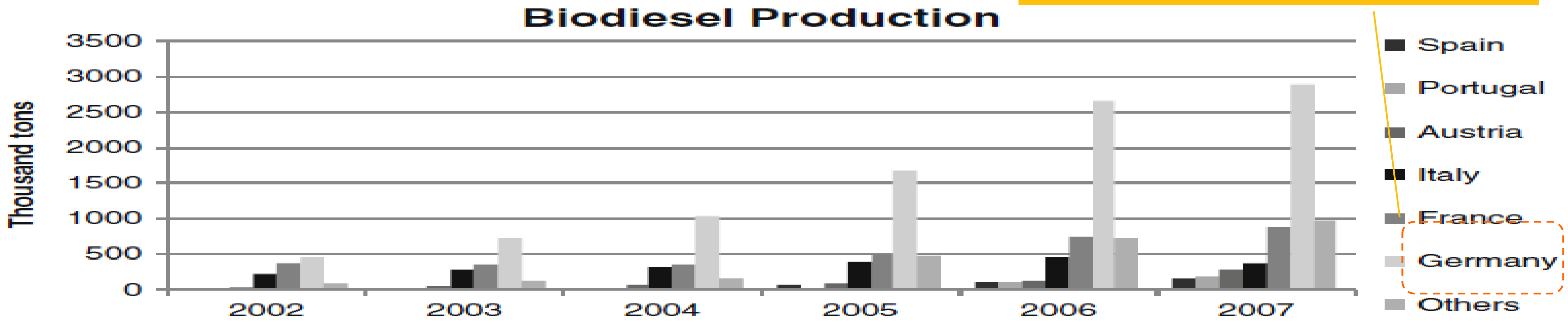
Overview:

- Set of subsidies, tax reductions, and exemptions:
  - Common Agricultural Policy (CAP) incentivises production of certain crops for energy use
  - Directives set targets of incorporation rates
- Strong import barriers
- Strongly oriented toward biodiesel

European Union biofuels programm



supply relies largely on wheat and sugar beet



supply relies largely on rapeseed

EU biofuels program challenges

Criticisms:

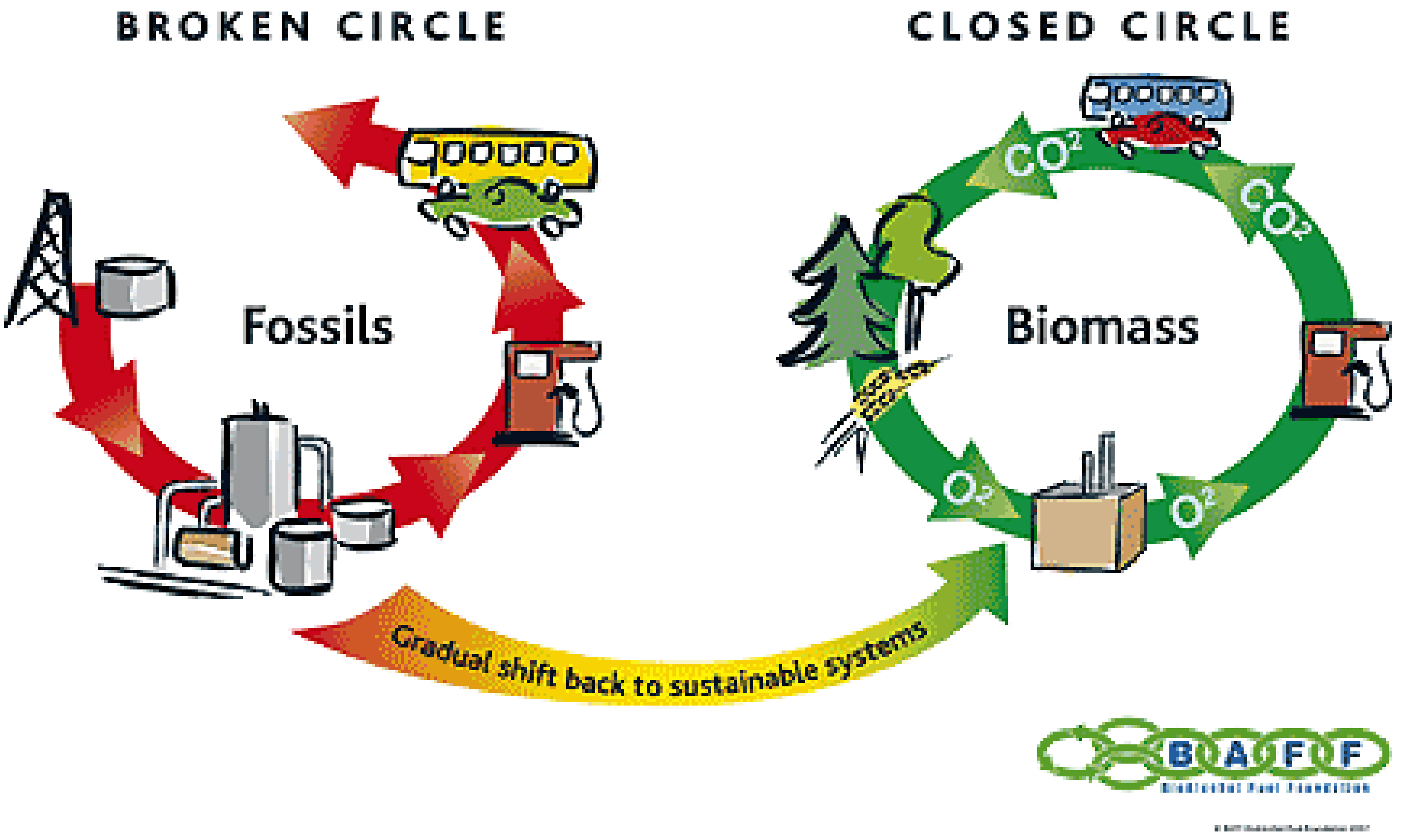
- Highly dependence on subsides (5.5–8.4 bil EUR) (EU 2015)
- Land use change (LUC)
  - Uncertain impact on direct- and indirect-LUC in developing countries (Land grabbing, deforestation, etc.)
  - Increasing global food prices
- Increase of GHG emissions
  - Production of more impactful biofuels than conventional diesel and gasoline

Sustainability of biofuels Production

All that glitters…

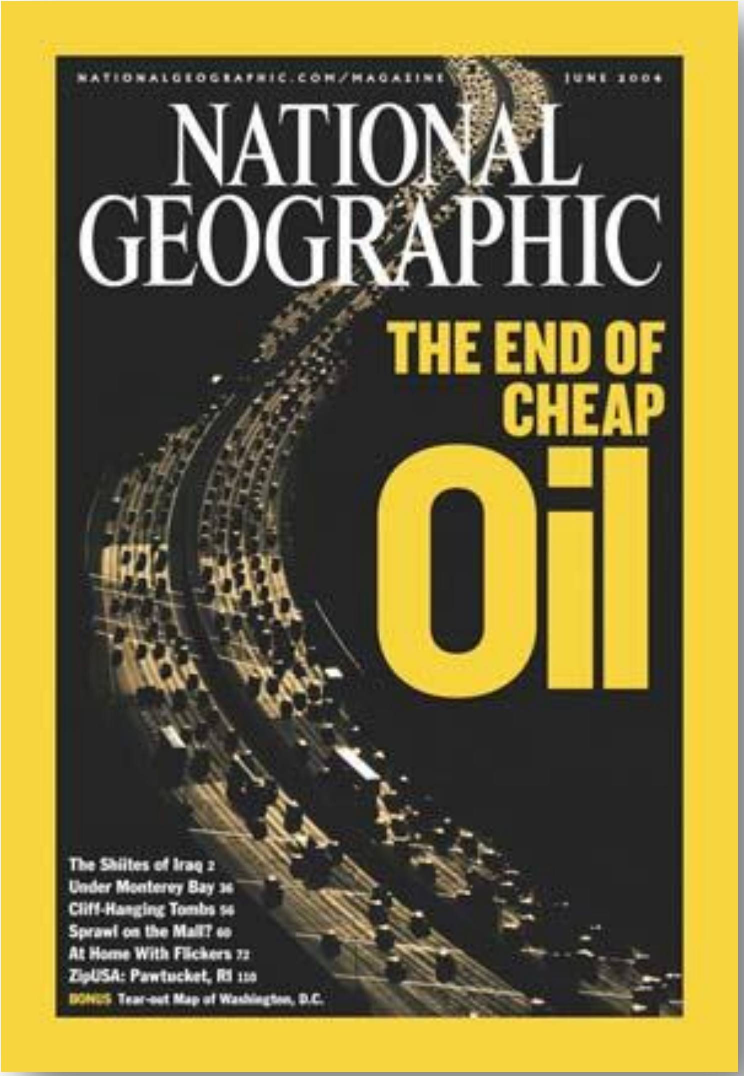
- Drivers

  Mitigation of climate change



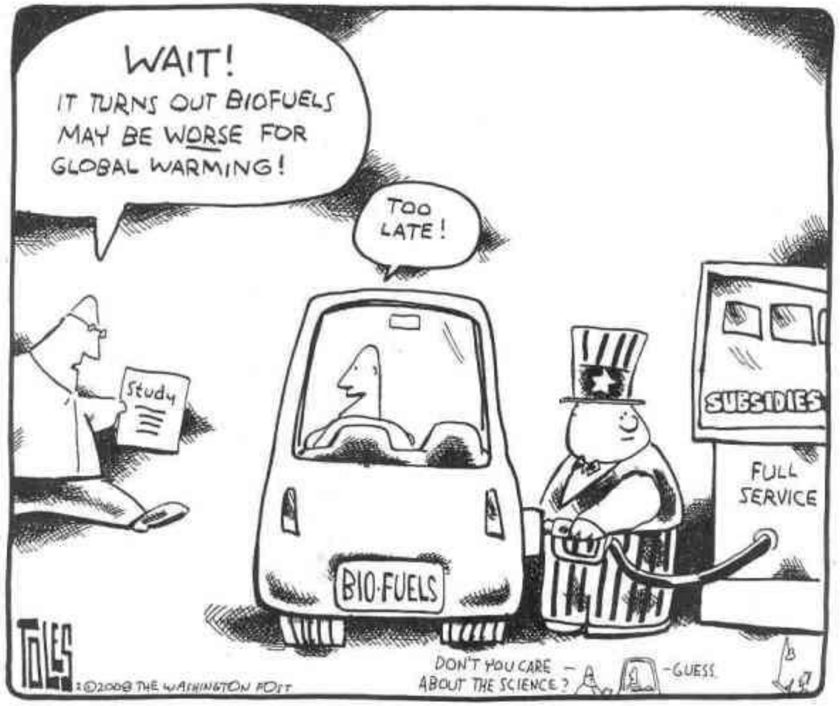
All that glitters…

- Energy security of supply
- Rural economic development

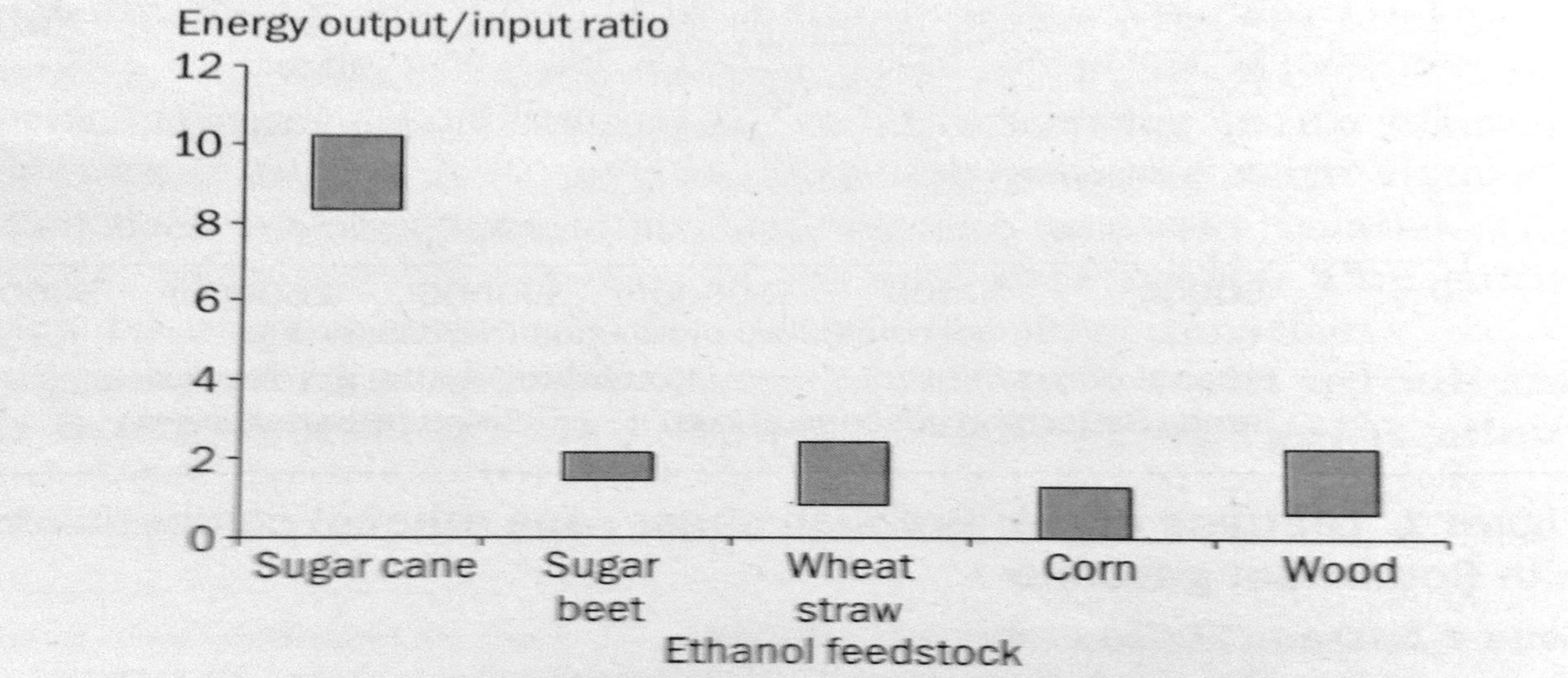


…is not gold

- Agricultural stage of biofuel production demands **high inputs** of fertilisers, pesticides and diesel → ↑ fossil fuel needs
- Biofuel refining requires heat, electricity and raw materials that might come from **fossil fuels**
- **Tailpipe emissions** of biofuel combustion might be higher than conventional fuels
- In some cases, biofuels are not beneficial when compared to fossil fuels

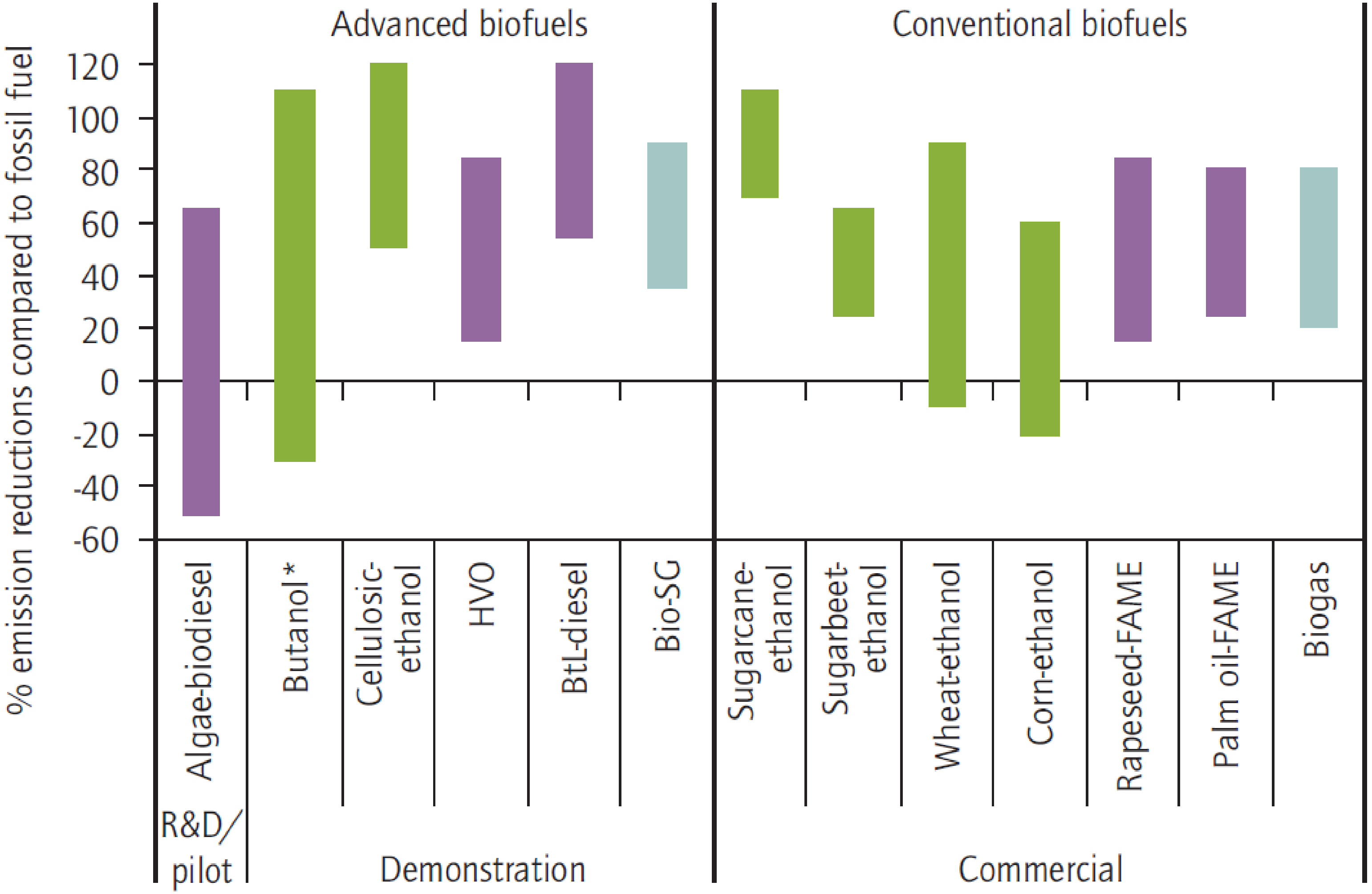


Non-renewable energy consumption



Source: Lucon et al. 2008

Global warming potential



Source: IEA/OECD 2012

Sugarcane ethanol shows significant potential for **GHG mitigation**, if no indirect land-use change occurs

Conventional biofuels: modest benefits (improvements might be achieved with use of co-products)

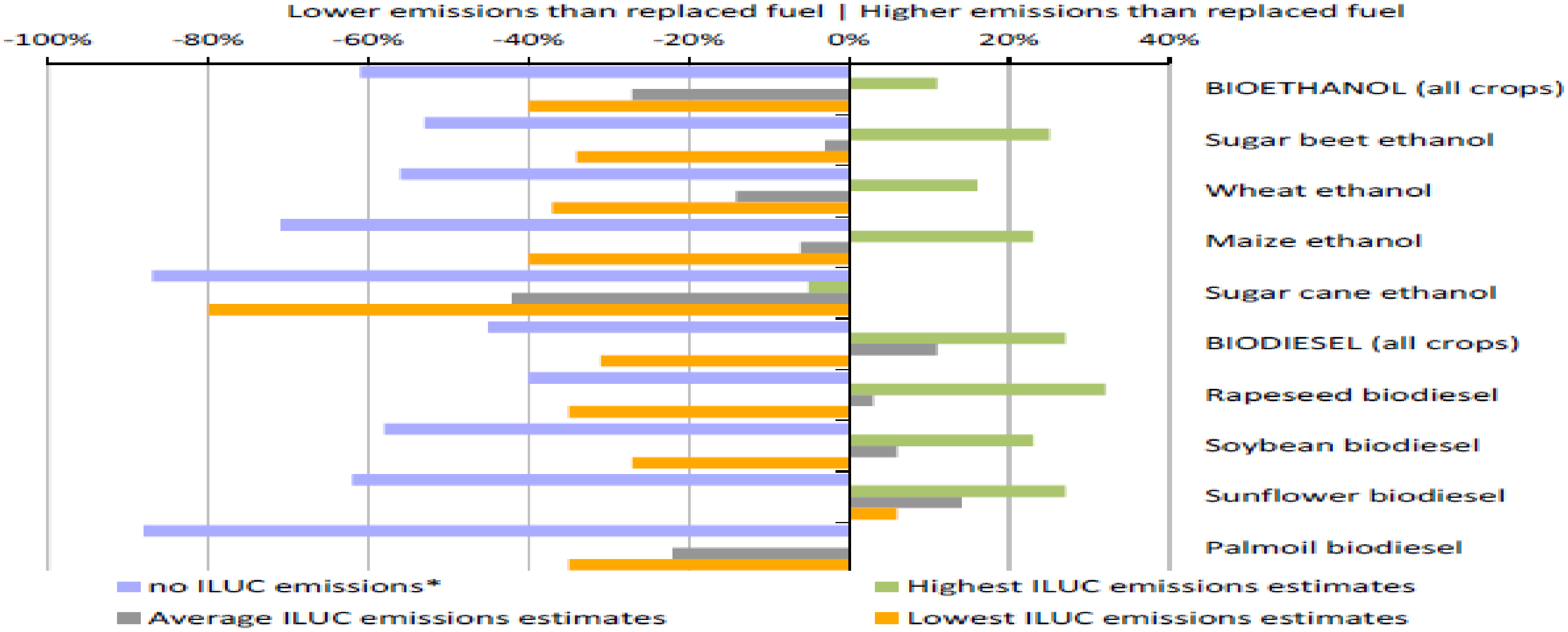
Advanced biofuels: higher potentials to reduce GHG emissions (in general)

High variability of life cycle results due to: feedstock, farming practices, use of co-products, methodology, reference systems

Global warming potential

Impacts of indirect Land use change

Figure 3 – Net CO_2 emissions of biofuels produced from selected crops, expressed as % of CO_2 emissions of fuel replaced

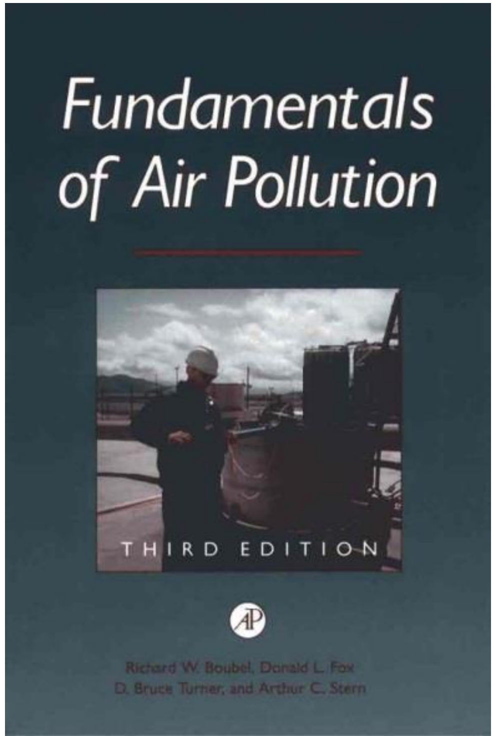


*based on typical GHG reduction savings from Renewable Energy Directive

Source: EU 2015

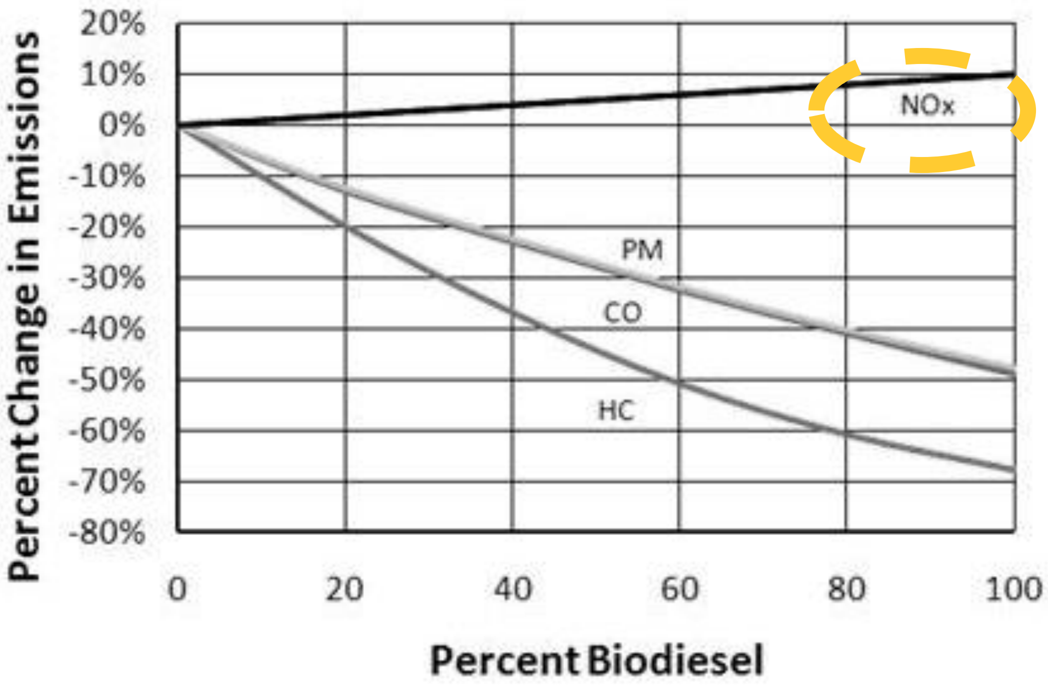
Local air pollution

- Tailpipe emissions of fuel combustion in vehicle engines difficult to predict
- Experimental results in laboratory and theoretical models do not match with real-time emissions
- **Emission factors depend upon**: kind of fuel used, use of catalysts, traffic conditions, cold-start conditions, driving behaviour, etc.
- Ethanol and biodiesel are oxygenated fuels: greater oxygen to the fuel mixture, **improving** the **efficiency of combustion**



Local air pollution

- If engines are not adjusted to new fuel/blend properties, local air **pollutants** might be **higher** than conventional fuels
- In general, biodiesel reduced HC, CO, PM, but NOx are a concern (↑ 10%):



EPA

A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions

Draft Technical Report

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Available online at www.sciencedirect.com

ScienceDirect

Science of the Total Environment 385 (2007) 146–159

Science of the Total Environment

www.elsevier.com/locate/scitotenv

A case study of real-world tailpipe emissions for school buses using a 20% biodiesel blend

Claudio Mazzoleni[a,*], Hampden D. Kuhns[a], Hans Moosmüller[a], Jay Witt[b,2], Nicholas J. Nussbaum[a], M.-C. Oliver Chang[a,1], Gayathri Parthasarathy[a], Suresh Kumar K. Nathagoundenpalayam[a], George Nikolich[a], John G. Watson[a]

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Journal of Cleaner Production

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Cleaner Production

Biodiesel's and advanced exhaust aftertreatment's combined effect on global warming and air pollution in EU road-freight transport

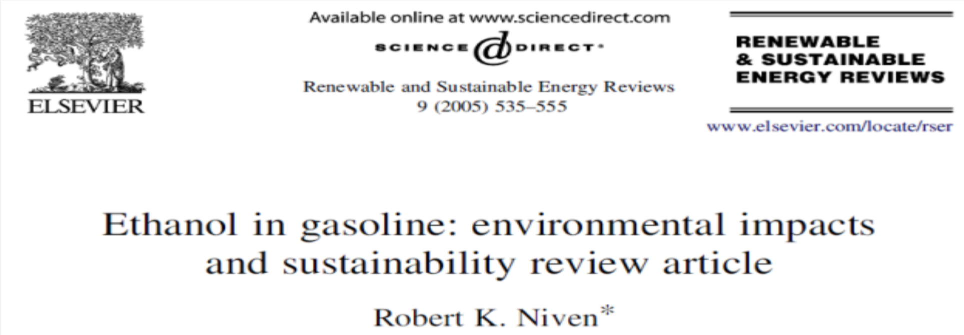
CrossMark

Geoffrey Gilpin[a,b,*], Ole Jørgen Hanssen[c,d], Jan Czerwinski[e]

Source: EPA, 2002

Local air pollution

- In general, ethanol combustion in Otto-cycle engines:
  - ↓CO, HC and PMs
  - aldehydes (mainly acetaldehyde) → tropospheric ozone, photochemical smog, human health issues
  - ↑ ↓ Nox
- Cold-weather emissions: catalytic converters used on vehicles have to warm up before they reach full efficiency, resulting in higher emissions



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9 (2005) 535–555
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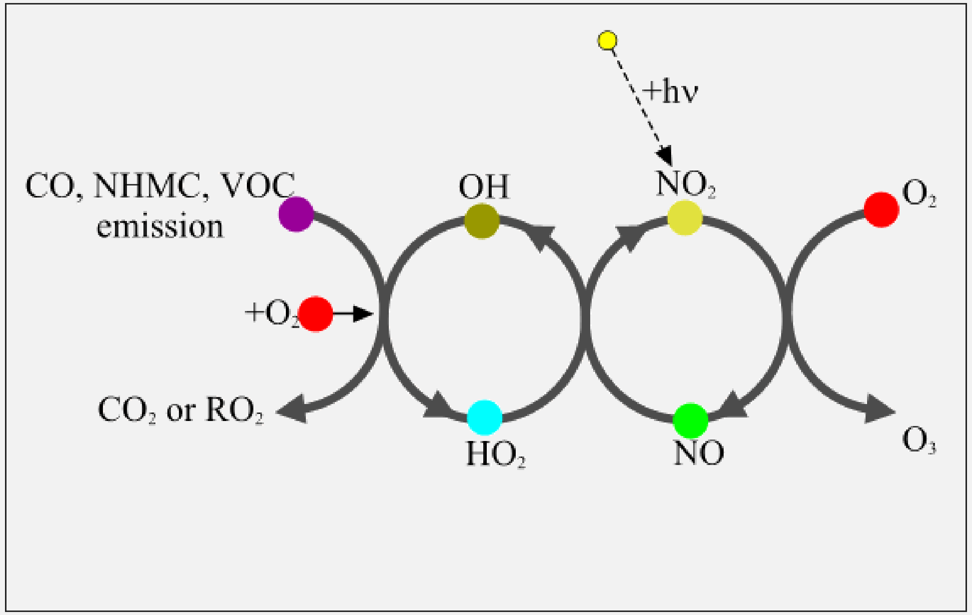
Ethanol in gasoline: environmental impacts and sustainability review article

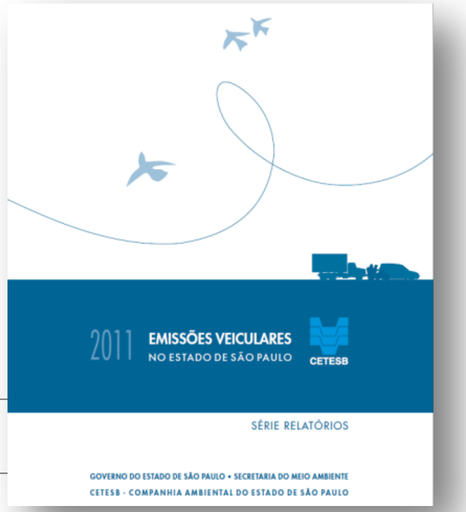
Robert K. Niven*

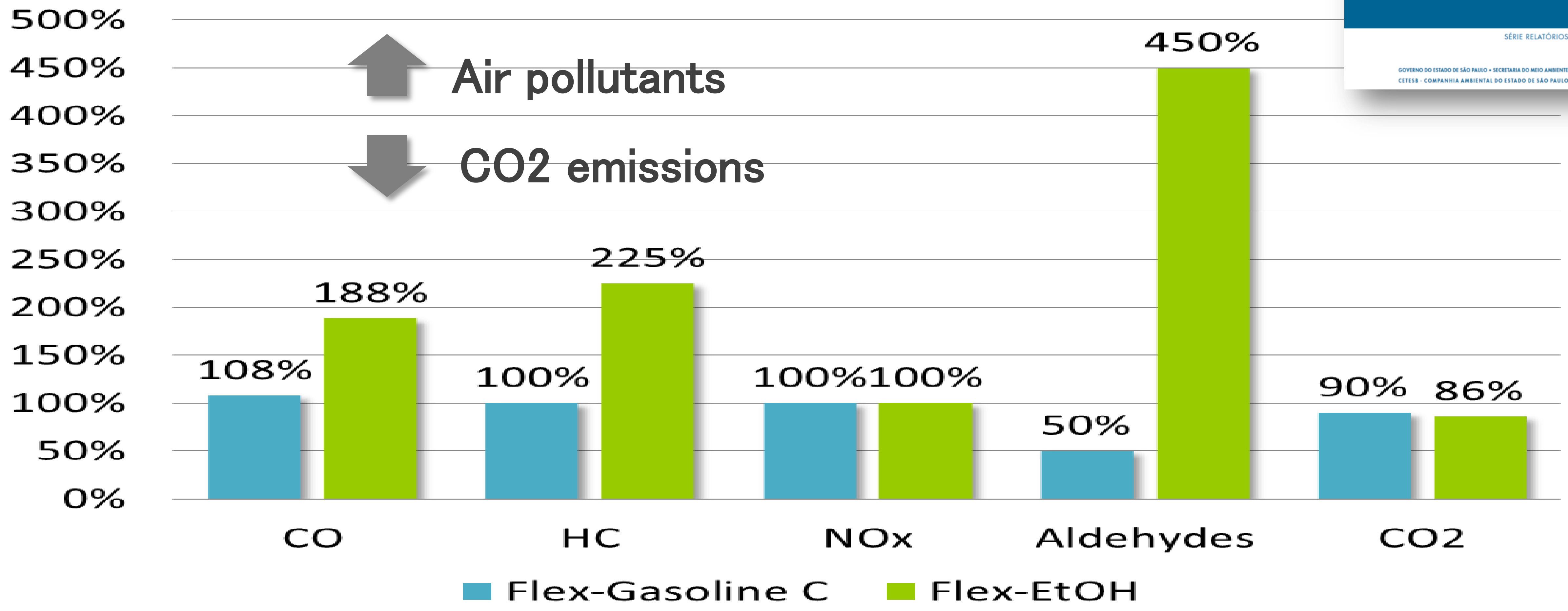


Source: EPA, 2002

Local air pollution

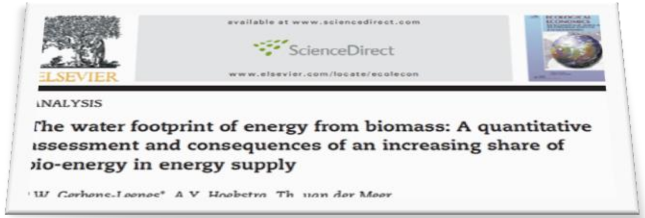
- Comparative emissions (g/km) of Flex-gasoline and Flex-ethanol vehicles with conventional gasoline vehicles (0% refers to conventional gasoline vehicles)





Source: CETESB 2011

Water footprint



- Biofuels production requires large amounts of water (irrigation and processing activities)

- Biofuels production generates large amounts of liquid effluents

Table 2 Green, blue and total WF for different modes of passenger transport in the EU, energy source and crop choice

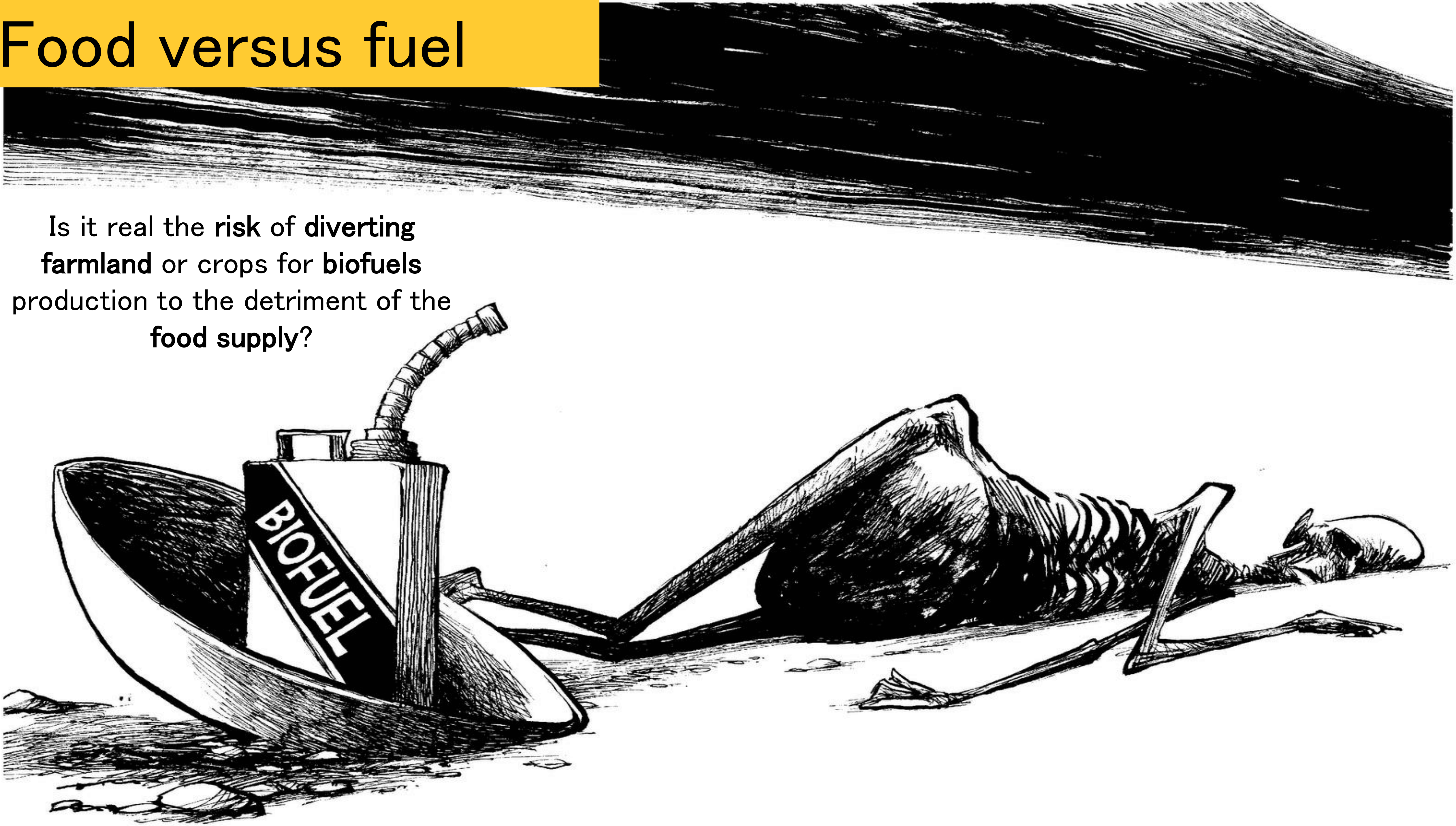
Transport mode	Energy source	Crop source	WF[a]/litre per passenger km		
			Green	Blue	Total
Airplane	Biodiesel	Rapeseed	142–403	0	142–403
	Bio-ethanol	Sugar beet	42–79	1–10	42–89
Car (large)	Biodiesel	Rapeseed	214–291	0	214–291
	Bio-ethanol	Sugar beet	136–257	2–32	138–289
Car (small efficient)	Biodiesel	Rapeseed	65–89	0	65–89
	Bio-ethanol	Sugar beet	23–44	0–5	24–50
Bus	Biodiesel	Rapeseed	67–126	0	67–126
	Bio-ethanol	Sugar beet	20–52	0–5	20–58
Train	Biodiesel	Rapeseed	15–40	0	15–40
Electric train	Bio-electricity	Maize	3–8	0–3	3–12
Electric car	Bio-electricity	Maize	4–5	1–2	4–7
Walking	Sugar	Sugar beet	3–5	0–1	3–6
Bike	Sugar	Sugar beet	1–2	0	1–2

[a] Results are based on first generation biofuels.

Source: Gerbens-Leenes & Hoekstra 2011

Food versus fuel

Is it real the **risk** of **diverting farmland** or crops for **biofuels** production to the detriment of the **food supply**?



Food versus fuel

- Literature diverges about this topic
- Uncertainty is related to the large number of impacts and feedback loops that can positively or negatively affect the price of food supply systems

"Large increases in biofuels production in the United States and Europe are the main reason behind the steep rise in global food prices", and also stated that "Brazil's sugar-based ethanol did not push food prices appreciably higher"

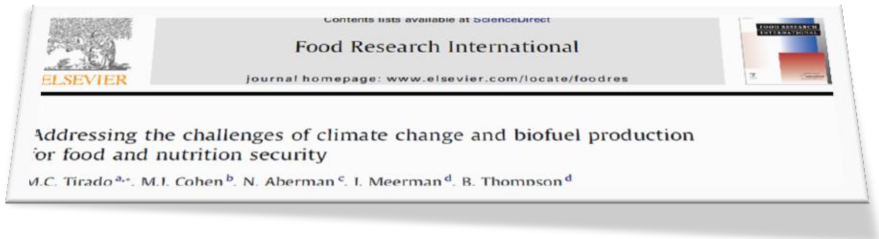
the World Bank, 2008

"The effect of biofuels on food prices has not been as large as originally thought, but that the use of commodities by financial investors (the so-called "financialisation of commodities") may have been partly responsible for the 2007/08 spike"

the World Bank 2010

Food versus fuel

- A common view in the literature:
  - The merger of agriculture and energy markets is one of the basis for the food crisis
  - Growing mechanisation of farming practices and its dependence to fossil fuel/fertilisers/pesticides are major reasons for the 2008 fuel crisis
  - Co-existence of biofuel and food production seems possible especially for non-food crop biofuels (advanced fuels)
  - Nevertheless… energy crop farming land is one of the factors pressuring land availability for food crops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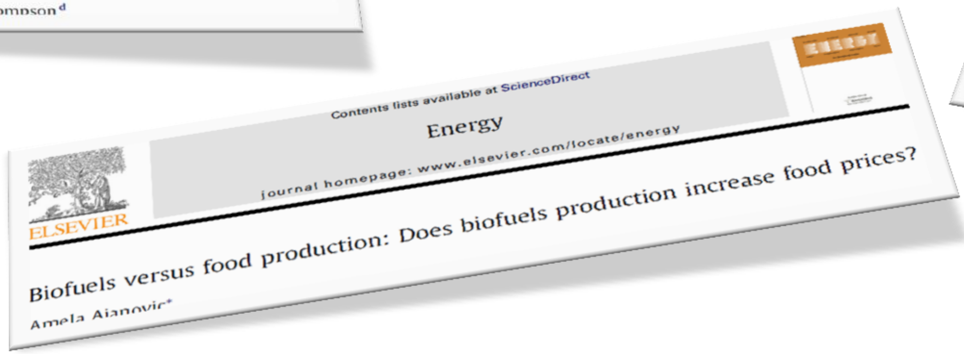
Addressing the challenges of climate change and biofuel production for food and nutrition security
M.C. Tirado, M.J. Cohen, N. Aberman, J. Meerman, B. Thompson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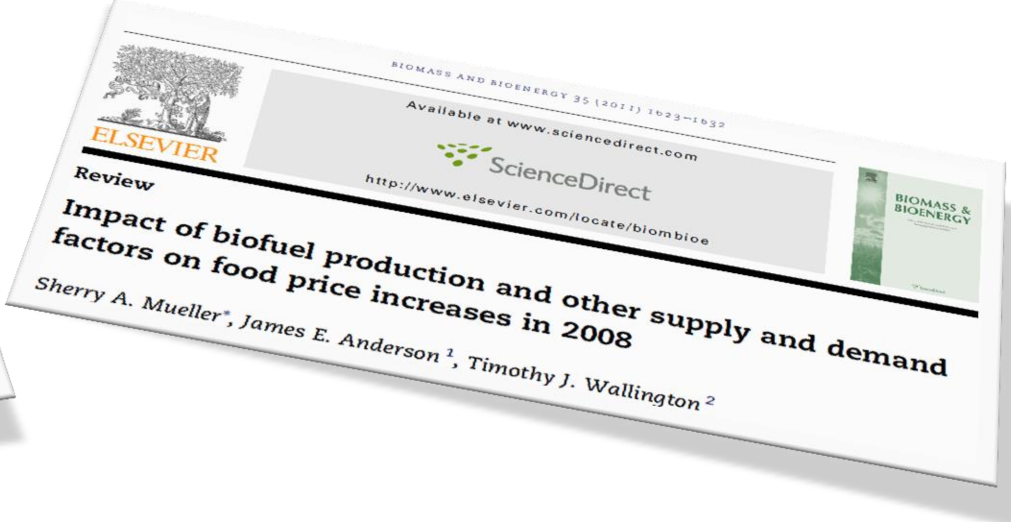
Biofuels versus food production: Does biofuels production increase food prices?
Amela Ajanovic


BIOMASS AND BIOENERGY 35 (2011) 1623–1632
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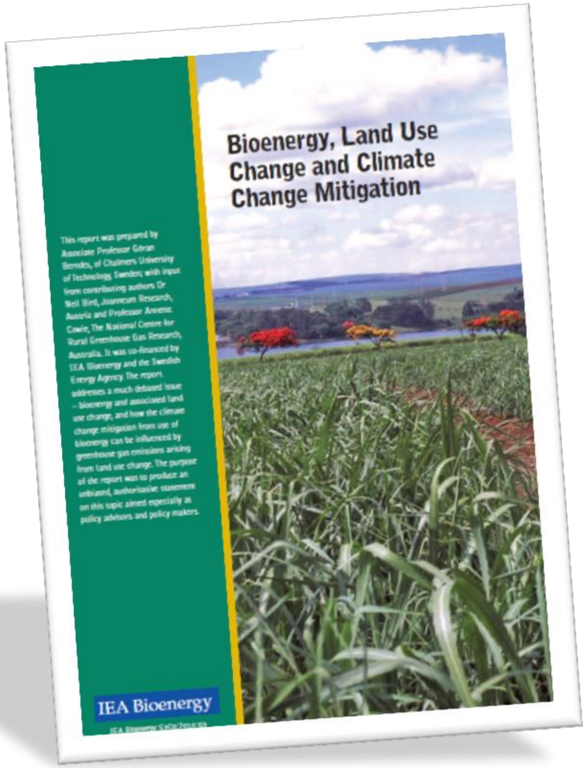
Review
Impact of biofuel production and other supply and demand factors on food price increases in 2008
Sherry A. Mueller, James E. Anderson, Timothy J. Wallington

Land use change

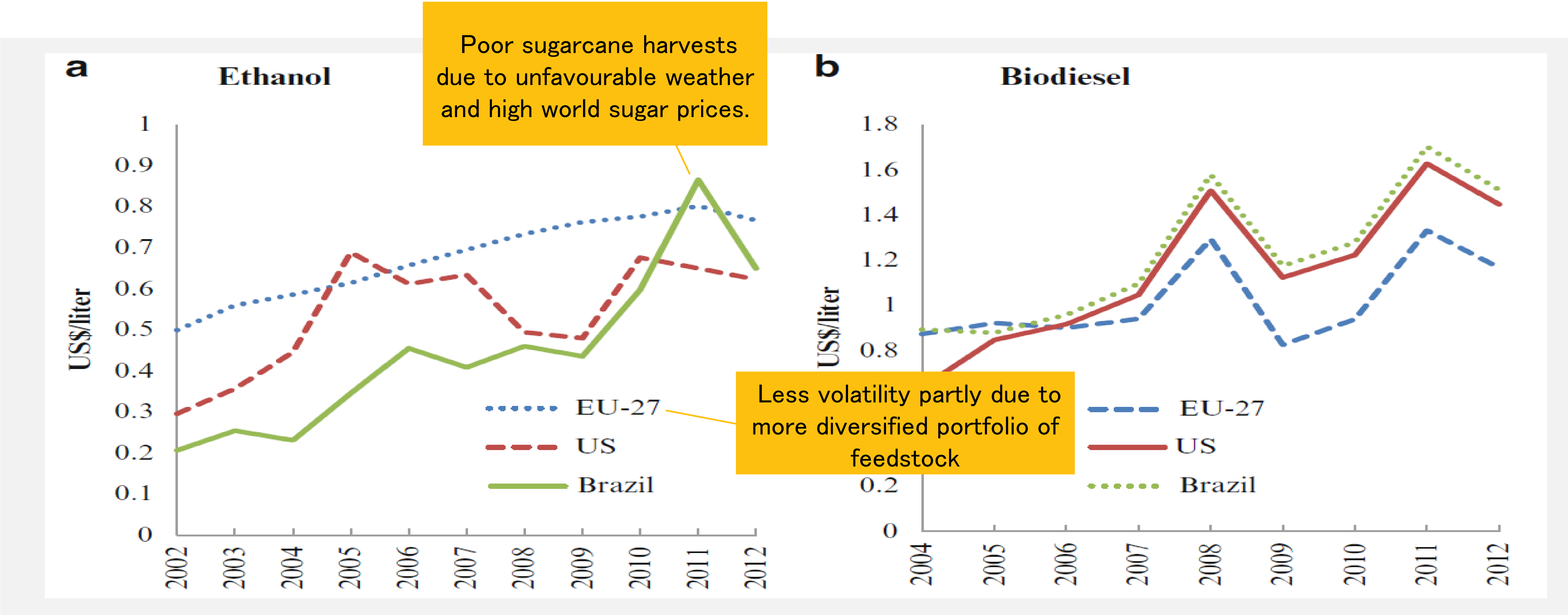
- Direct impacts
  - When biofuels feedstocks are grown on land that was previously forest
  - Associated GHG emissions related to conversion of land with high carbon stocks must be avoided (IPCC, IEA methodologies)
- Indirect impacts
  - When biofuel production displaces the production of other commodities, which are then produced on land converted elsewhere (perhaps in another region or country)
  - More difficult to identify and model explicitly in GHG balances (no consensus in literature)



Economic Perspectives

Biofuel production prices

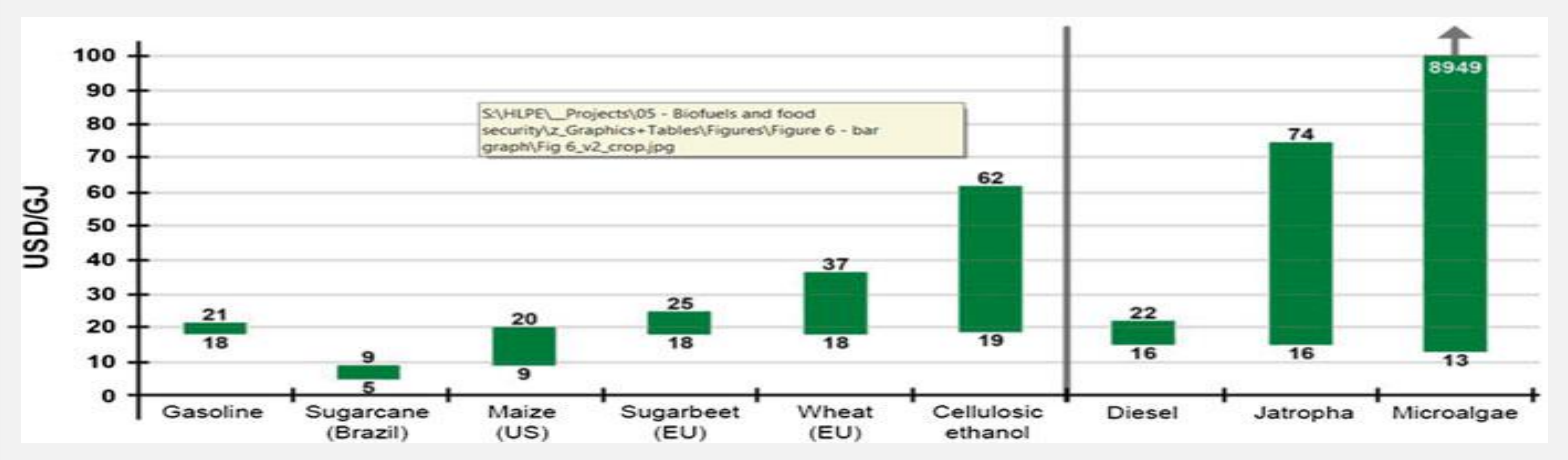
- Prices are subject to:
  - Volatility in the commodities markets for the conventional biofuel feedstocks (corn, sugarcane, soybeans, palm oil, etc.)
  - Weather conditions



Source: Timilsina and Zibelman 2014

Biofuels production costs

- Costs are subject to:
  - Feedstock cost (70% for corn-ethanol, 85-90% for biodiesel)
  - Scale of the plant
  - Processing technology
- Conventional fuels are highly dependent on feedstock volatility (45-70%)
- Use of co-products: ↓ up to 20%



Source: Timilsina and Zibelman 2014

Job creation: Brazilian sugarcane ethanol

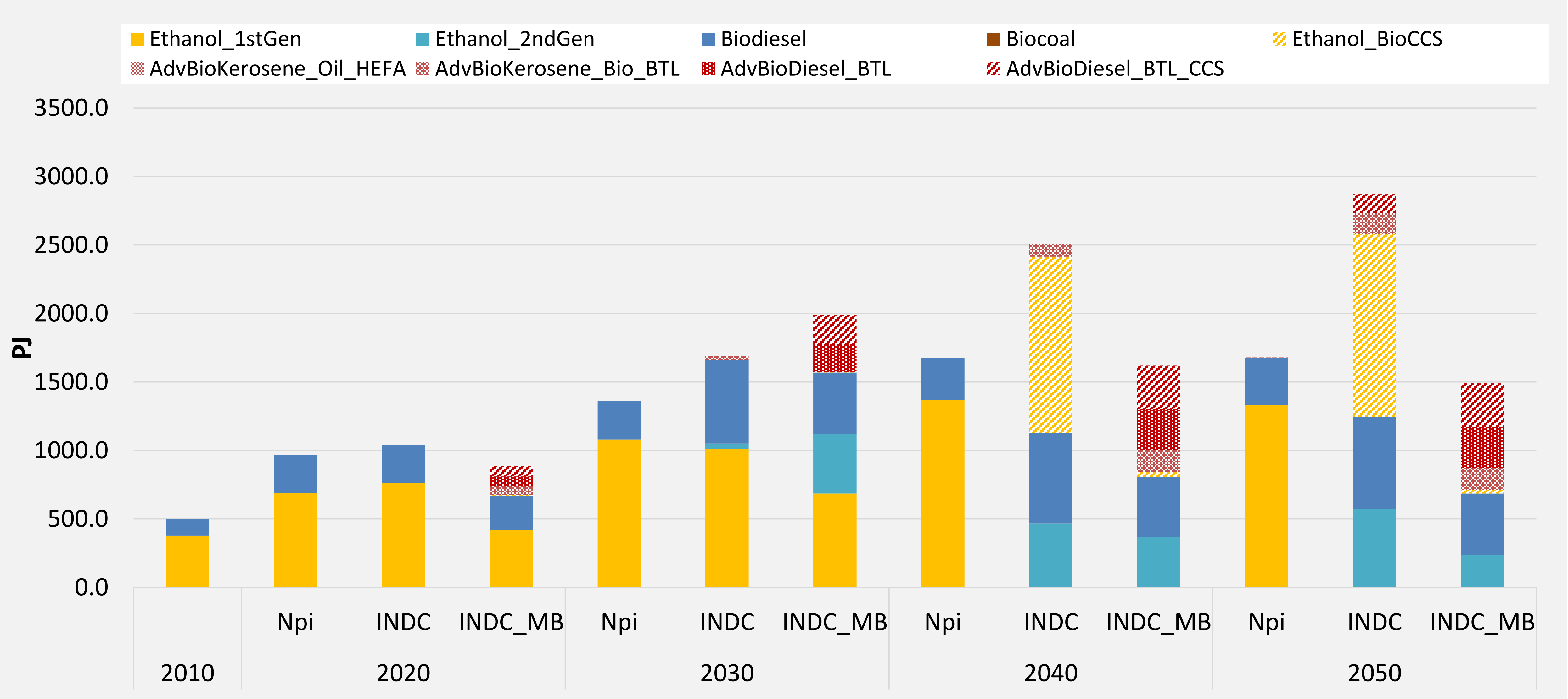
- Feedstock production is relatively unskilled labour intensive (informal, temporary and child labour)
- Sugarcane agroindustry is a major job generator (~1.1million direct jobs as for 2012) (UNICA, 2013)
- Harvest mechanisation will reduce the overall number of jobs by 60%, but will required higher level of skilled workers

Activity	Region	Year			
		2000	2002	2004	2005
Sugarcane production	North Northeast	81,191	86,329	104,820	100,494
	Central-South	275,795	281,291	283,820	314,174
	Brazil	356,986	367,620	388,121	414,668
Sugar production	North Northeast	143,303	174,934	211,864	232,120
	Central-South	74,421	126,939	193,626	207,453
	Brazil	217,724	301,873	405,490	439,573
Bioethanol production	North Northeast	25,730	28,244	26,342	31,829
	Central-South	42,408	66,856	80,815	96,534
	Brazil	68,138	95,100	107,157	128,363
All	Brazil	642,848	764,593	900,768	982,604

Source: Moraes 2005, *apud* Nogueira 2008

Final considerations

How will the future look like for biofuels in Brazil? Some scenarios



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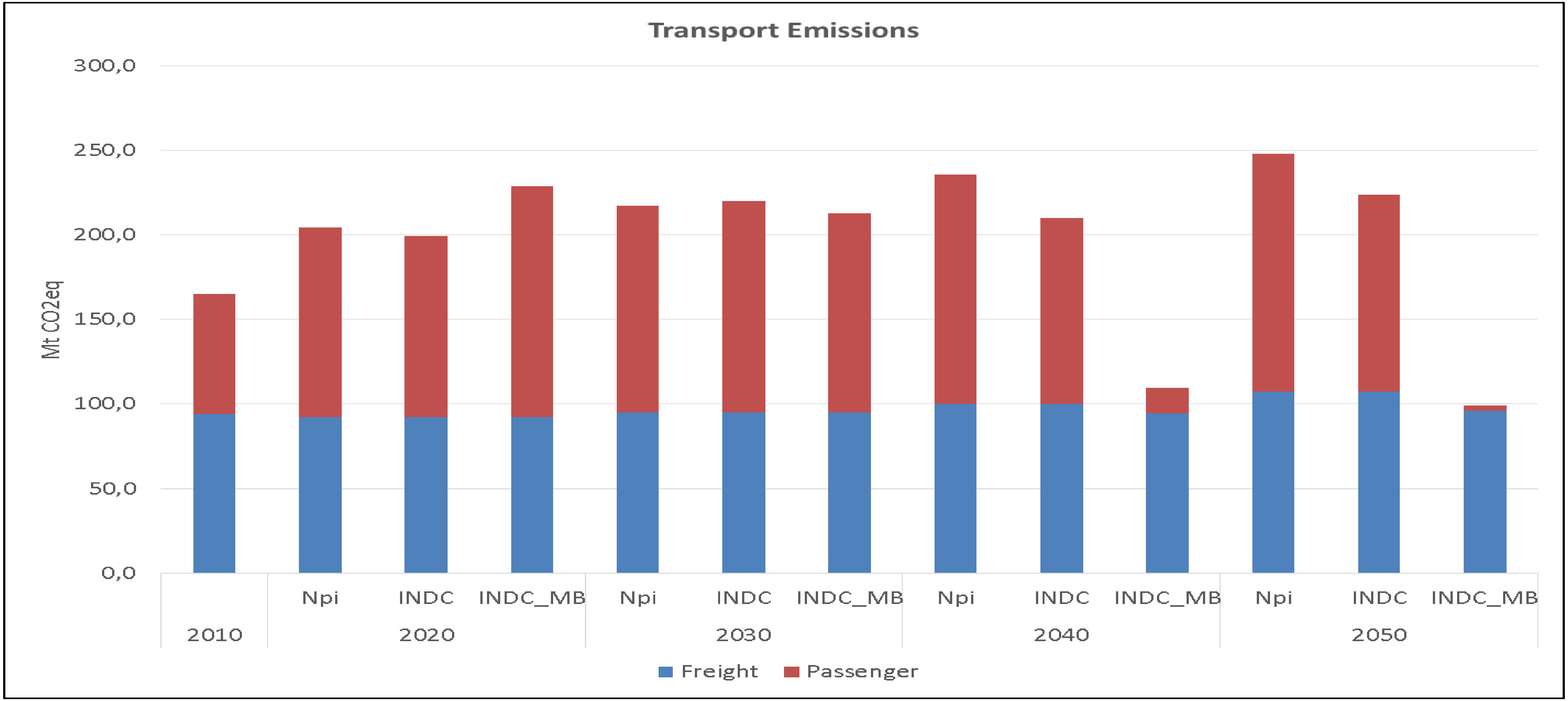
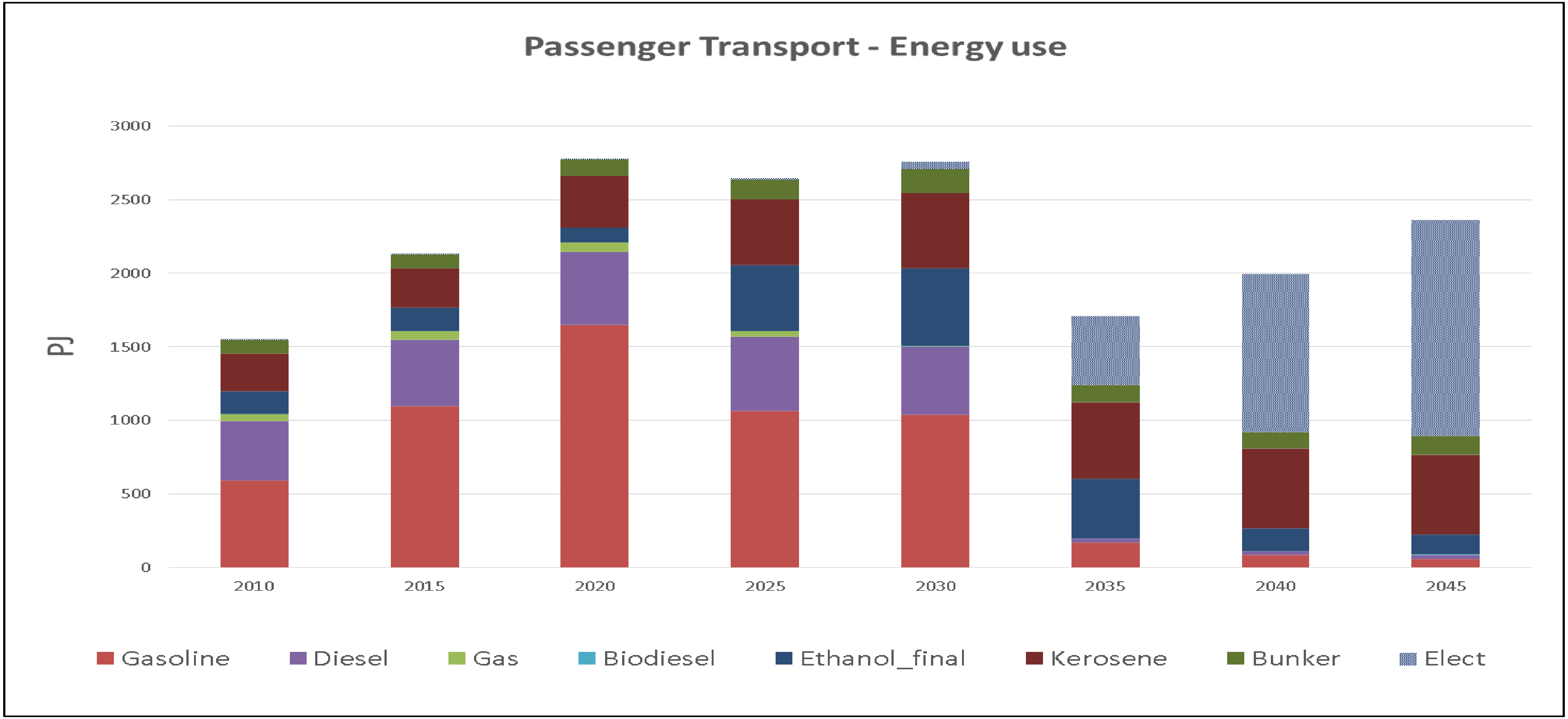


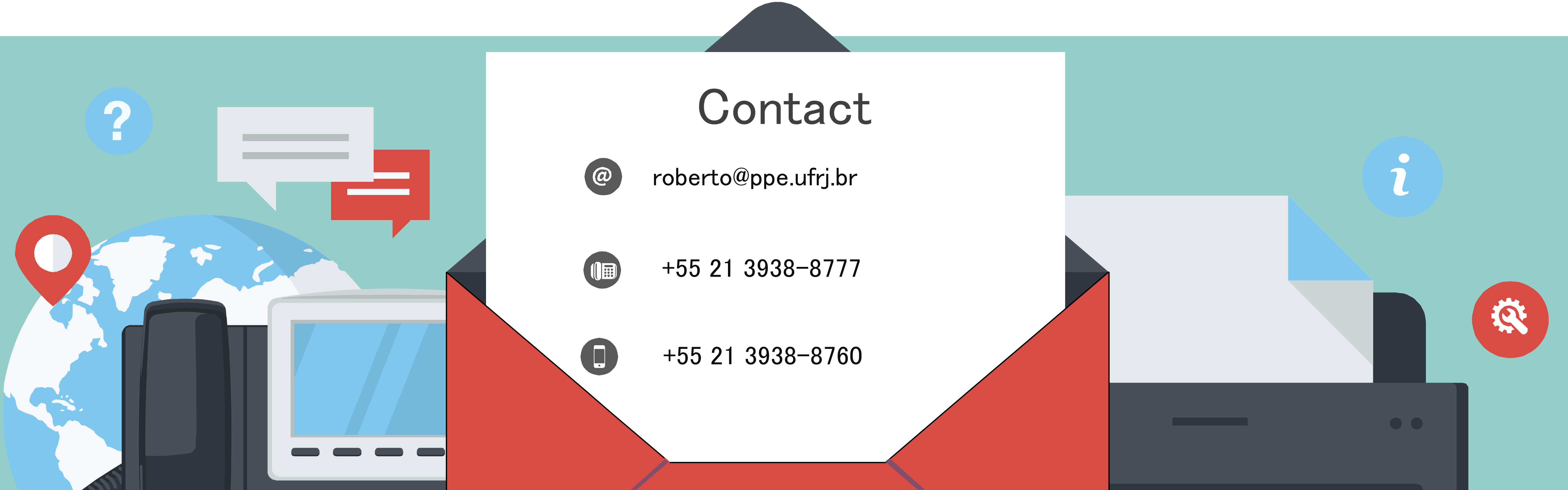
How will the future look like for biofuels in Brazil? Some scenarios



Summary

- Biofuels programs were historically motivated by issues of energy security and agriculture support policies (now, more and more, by climate mitigation), with not much concern for environmental issues
- Brazil has had a long tradition of sugarcane ethanol and biodiesel production, where technology learning has always played a very importante role
- The successfull inclusion of biofuels in the Brazilian fuels structure has been a result of a combination of leverage mechanisms, which acted in the different parts of the ethanol´s and biodiesel´s value chains
- But if the past and the present may have looked, or still look, bright for the biofuels industry in Brazil (as well as in the US), the future looks very uncertain
- Signals from many different fronts, both domestically and from abroad, point in the direction of an increasing electrification of the transport sector over time, at least for those segments that can be more easily electrified
- Changes in human behaviour and habits, mainly among youngsters, as well as new disruptive transportation technologies, should not be dowplayed, even in the short to medium terms

Thanks for listening!




Rio de Janeiro
Brazil

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