

**Analysis of the Viability of
Ethanol Production in Brazil:
Economical, Social and
Environmental Implications**

**Isabel Alvarez Murillo – MCGILL
UNIVERSITY**

**RCN Conference on Pan American
Biofuels and Bioenergy Sustainability**

22-25 July 2014, Recife, Brazil

Presentation¹ outline:

- Background
 - Biofuel industry
 - Ethanol
 - Brazil's production
- Repercussions
 - Economical
 - Environmental
 - Social
- Discussion



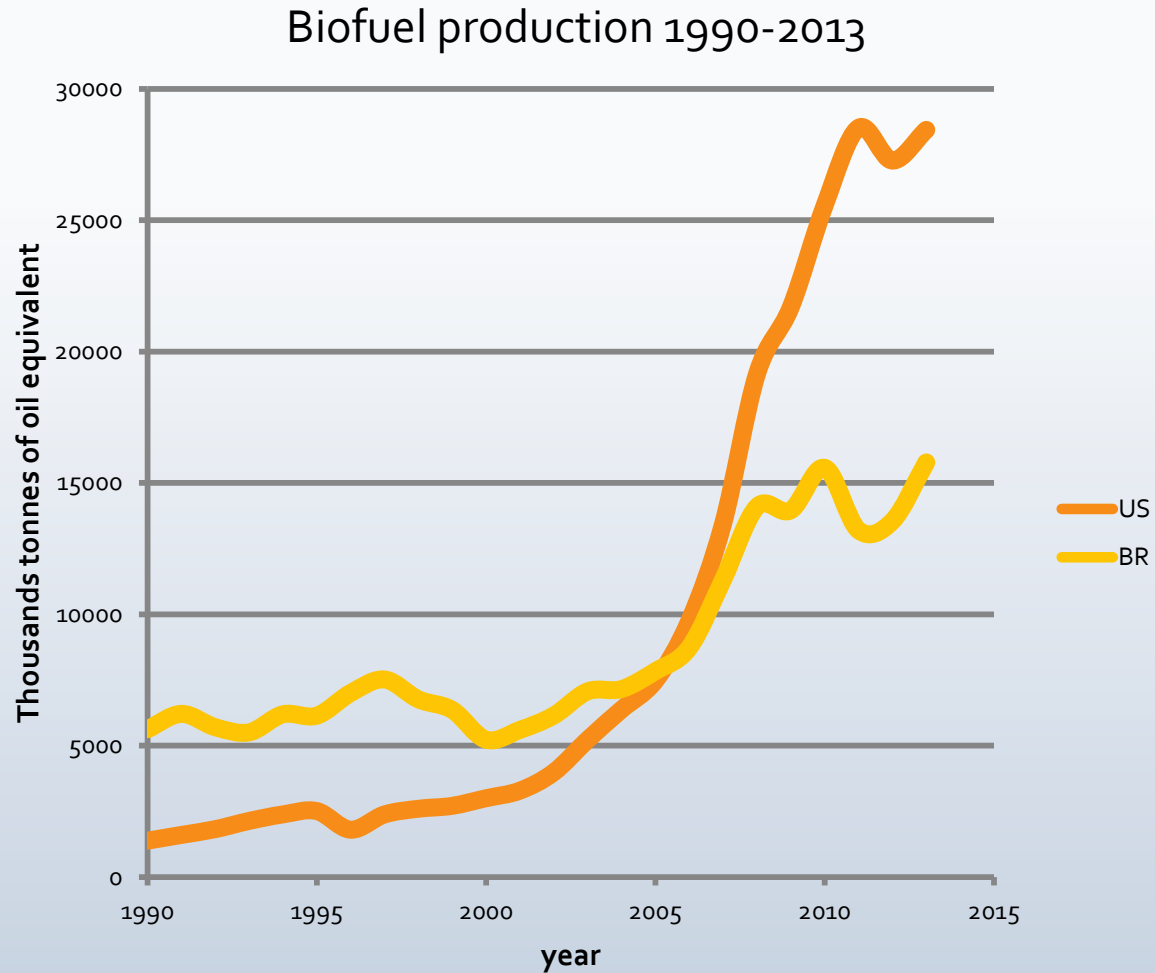
¹Based on Alvarez Murillo, I. 2013. Analysis of the viability of ethanol production in Brazil: Economical, social & environmental implications. *Energy and Environment Research* 3 (2): 166-175. doi:10.5539/eer.v3n2p166

Background



Overview of Global Energy Production

- Global energy consumption grew by 2.5% in 2011
- Brazil leader in biofuel exports in 2007
- Global biofuel production only grew by 0.7% in 2011



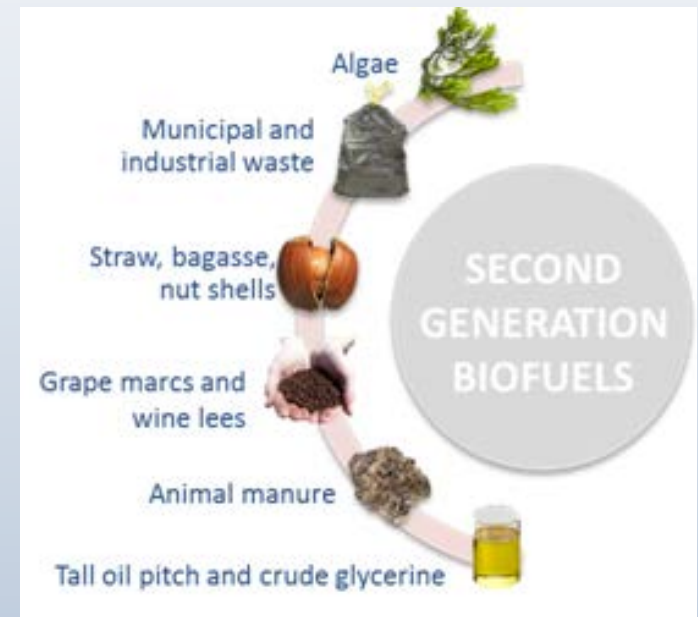
First-generation Biofuels

- Corn:
 - Average production rate 3.3 thousand liters per hectare¹
 - Net energy yield of only 20%
 - Advantages: fairly easy conversion from starch to ethanol
- Sugarcane
 - Average production 6.1 thousand liters per hectare¹
 - Advantages: more easily conversion only fermentation
 - Carbon dioxide emissions can be lowered by 90% compared to gasoline



Second-generation biofuels

- Feedstock not suitable for human consumption grown in marginal lands
- Conversion: thermo-chemical and biochemical
- Feedstock: grasses, jatropha, waste vegetable oil and municipal solid waste.
- Advantages:
 - Low fertilizer needs
 - Direct use as biomass
 - Net energy yield to energy input ratio 5.4
- Disadvantages:
 - Lengthy growth
 - High water demand



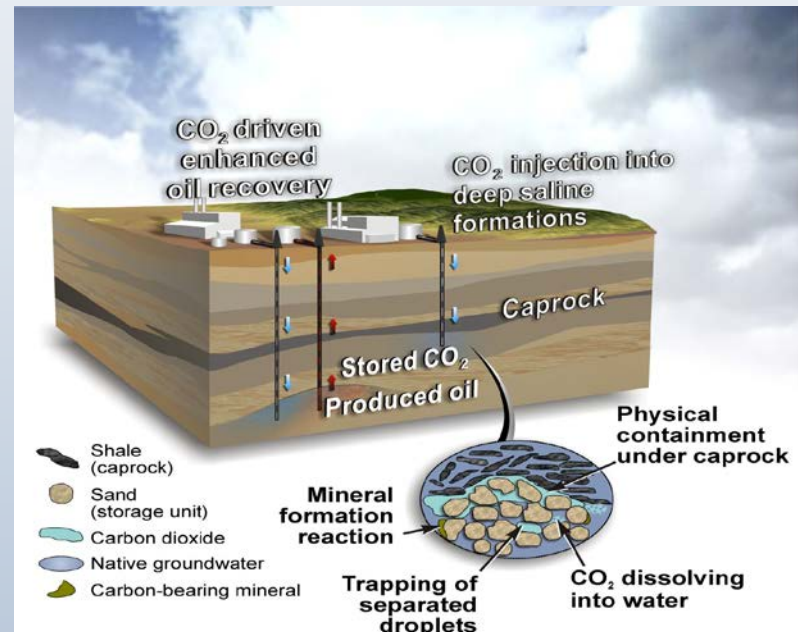
Third-generation Biofuels

- Average production yield 84.2 thousand-liters per hectare¹
- Advantages:
 - Algae can be genetically manipulated to directly produce: biodiesel, butanol, gasoline and diesel fuel.
 - Capable of growing anywhere where temperatures are high
- Disadvantages:
 - Require significant amounts of water and nutrients to grow
 - Cultivated in: open ponds, closed-loop systems, photo-bioreactors
 - Advancement in plant biology has improved crop yields



Fourth-generation Biofuels

- Carbon-negative
- Bioconversion process: fermentation, gasification and fast-pyrolisis
- Carbon dioxide captured using pre-combustion, oxyfuel or post-combustion processes
- Accumulated in depleted oil and gas fields or saline aquifers
- New developments



Brazilian ethanol production

- 1930: Bio-ethanol production started
- 1973: Arab oil embargo
- 1974: Brazilian National Alcohol Program
- 2007: International interest in global warming
- Advantages:
 - Reduction in greenhouse gas emissions
 - Lesser dependence of fossil fuels
 - Job creation
 - Income and foreign investment opportunities

Table 1: Top 25 Countries, Ethanol Production Capacity¹

Rank	Country	Million Liters	Million Gallons
1	United States	51,415.97	13,584.14
2	Brazil	26,887.52	7,103.70
3	China	2,699.48	713.20
4	France	1,821.03	481.12
5	Canada	1,494.50	394.85
6	India	1,420.92	375.41
7	Poland	1,079.00	285.07
8	Germany	916.97	242.26
9	Thailand	868.50	229.46
10	Jamaica	832.70	220.00
11	T & T	757.00	200.00
12	Indonesia	683.38	180.55
13	Spain	546.00	144.25
14	Austria	485.00	128.14
15	Belgium	485.00	128.14
16	Netherlands	480.00	126.82
17	United Kingdom	470.00	124.17
18	US Virgin Islands	387.50	102.38
19	Colombia	352.00	93.00
20	Vietnam	318.11	84.04
21	Australia	292.70	77.33
22	Czech Republic	280.00	73.98
23	El Salvador	247.10	65.28
24	Paraguay	237.25	62.68
25	Argentina	237.20	62.67
	Total	95,694.83	25,282.65

¹ Global Biofuels Center (2012) in Alvarez Murillo (2013)

Brazilian ethanol production (2011)

- Ethanol is the main biofuel used in the transportation sector
- Brazil is the 2nd major ethanol producer and greatest exporter
- Sugar and ethanol industry represent 2.3% of the Gross Domestic Product
- Generates 4.5 million jobs
- Sugarcane occupies 8 million hectares
- Sugarcane production of 600 million tons per year
- Largest sugar cane producer worldwide

Repercussions



Economical Impacts

- In 2012, Brazil's ethanol output showed its greatest decline since 1965 (-15.3%)
- By 2015, more biofuel production is expected to use cellulose as an input, rather than food crops.
- Global ethanol production expected to reach 180 billion liters per year by 2021.
- Three major leaders: United States, Brazil and European Union
- Possibility of their future replacement by advanced biofuels

Economical Impacts

- The policies developed in the United States by the Environmental Protection Agency (EPA) will affect the ethanol market on a global scale
- Three alternative implementation options
 - Lowering the total and advanced mandates by the shortfall in the cellulosic mandate
 - **Maintaining both the advanced and total mandates**
 - Maintaining the total mandate and lower the advanced mandate by the shortfall in cellulosic production

Economical Impacts

- Baseline projections: cellulosic ethanol production gradual increase 2011-2021 to reach 16 billion liters per year
 1. Expansion of 9% in sugarcane acreage compared to baseline
 2. Brazilian ethanol demand will decrease significantly
 3. Increase imports to meet domestic demand expected to reach 18 billion liters per year
- Brazil's dependency on foreign policies will create a source of economic vulnerability given the United States' policies significant influence on Brazil's ethanol and sugar markets.

Environmental Impacts

Greenhouse Gas Emissions

- Comparative energy analysis of biofuels vs. fossil fuels
- Fertilization of sugarcane production can lead to the soil-mediated release of nitrous oxide (NO₂) and methane (CH₄)
- Deforestation arising from land-use shifts towards agriculture contributes to 75% of Brazil's carbon dioxide (CO₂) emissions¹
- Brazil contributes to 3% of the global greenhouse gas emissions (4th)¹
- Production of biofuels are not totally independent from fossil fuels

¹ Ross (2012) in Alvarez Murillo (2013)

Environmental Impacts

Greenhouse Gas Emissions

- Expansion of sugarcane into cattle farms has created pressure towards further deforestation

- No restrictions on purchasing land to raise cattle



- Exacerbates deforestation and increases methane emissions from cattle

Environmental Impacts

Water Requirements and Water Pollution

- Most sugarcane grown under rainfed conditions
- It takes 2000 L of water to produce 1 L of biofuel from sugarcane
- In the northeast of Brazil agriculture is supported through irrigation
- Fertilizers and pesticides used in sugarcane plantations contain nitrogen and phosphorus



Environmental Impacts

Climate Change and Biodiversity

- Cerrado region is the world's most diverse savannah
- Currently 2-3 times as much annual deforestation compared to 2005-2006
- Clearing the Cerrado can have severe repercussions on global biodiversity
- Shifting rainfall patterns and increasing evaporation rates will increase the risk of desertification



Social Impacts

Land Tenure and Workers

- Expulsion of small farmers from their lands by large-scale ethanol producers (1970 -1980)
- Concentration of income to producers and processors
- Displacement of family workers
- Employees work conditions undermines health
- 80% of sugarcane is cut manually by approximately 1 million seasonal workers



Social Impacts

Food Security

- Increasing demand for biofuels resulted in an increasing demand for agricultural products
- Dramatic increase in food prices 2005-2008 had a devastating effect on the urban or landless poor
- In 1970, Pernambuco State led the country in sugarcane production but ranked among the poorest regions in the world
- Increase vulnerability of the poorest sectors since a small increase in food prices can dramatically change food availability to households

Social Impacts

Indigenous Populations: Guarani-Kaiowa

- Mato Grosso do Sul is currently seeing rapid expansion of soybean and sugarcane cultivation
- Threatened by the expansion of farms and landowners' violence
- Landowners have resorted to armed attacks on native encampments



Social Impacts

Indigenous Populations: Guarani-Kaiowa

- Sep 29th 2012: The Federal Court of Navarai dispatched an order to expel communities from the riverside
- Petition to the Brazilian Government to enact their collective death
- Lack access to food, proper settlements, medical services or protection from farmer's gunman
- These lands have not yet been demarcated by the federal government and the legal vacuum has fueled conflict



Discussion



Discussion

- Biofuels cannot be seen as the 'miracle solution' to the world's dependency on fossil fuels
- The implications of biofuels in Brazil are enormous
- Brazil is considered one of the most economically unequal countries in the world
- The economic benefits go to the wealthy countries that can purchase ethanol and the wealthy landowners, producers and processors that are part of this market
- The viability of ethanol's market in Brazil needs to be reconsidered

Thank you