

Energy Issues in Brazil



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Objectives

1. Discuss the main sources of Brazil's energy
2. Discuss the positive and negative effects of said sources
3. Discuss the effectiveness of each energy source
4. Globally compare energy sourcing
5. Estimate the future for Brazilian energy

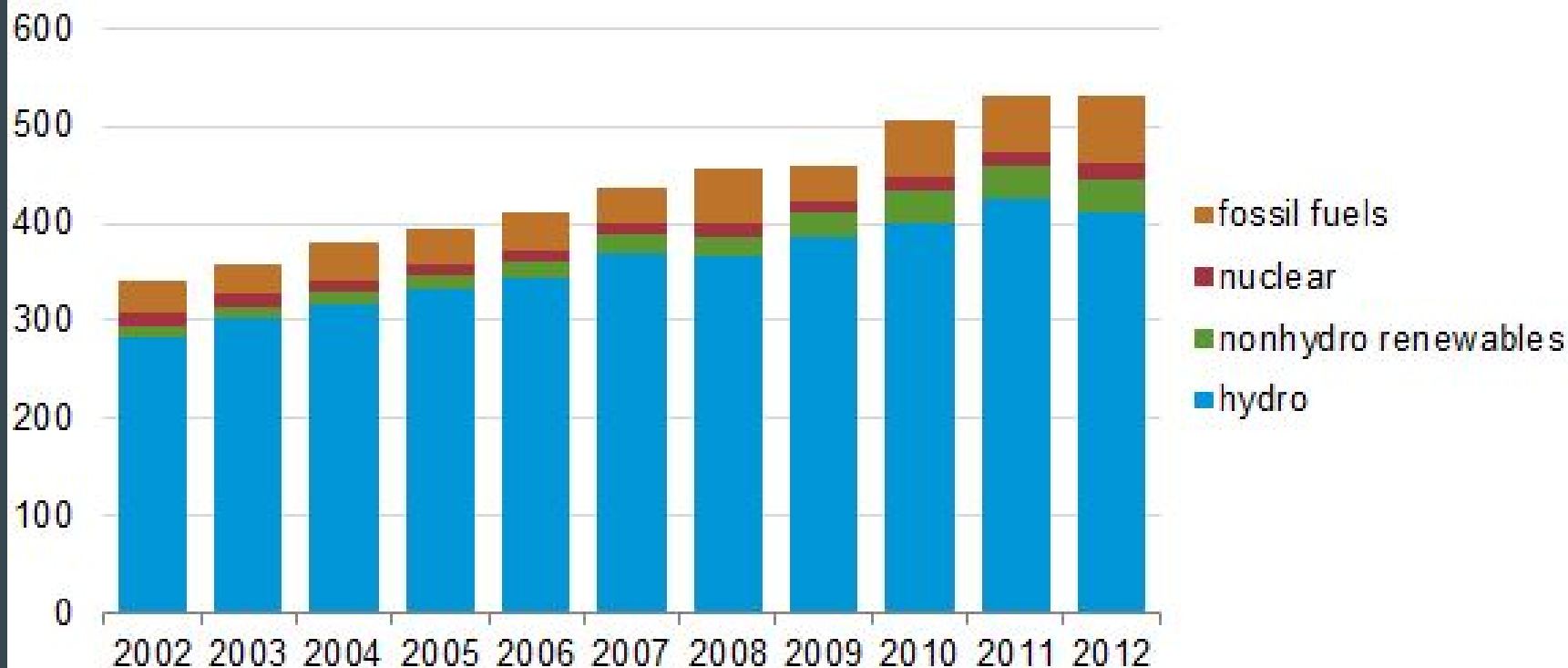
Energy Sources

Brazil's main energy sources can be separated into 6 categories...

1. Oil
2. Wind
3. Biofuels
4. Hydroelectric
5. Solar
6. Hydrogen

Brazil's electricity generation by fuel type (2002-12)

billion kilowatthours

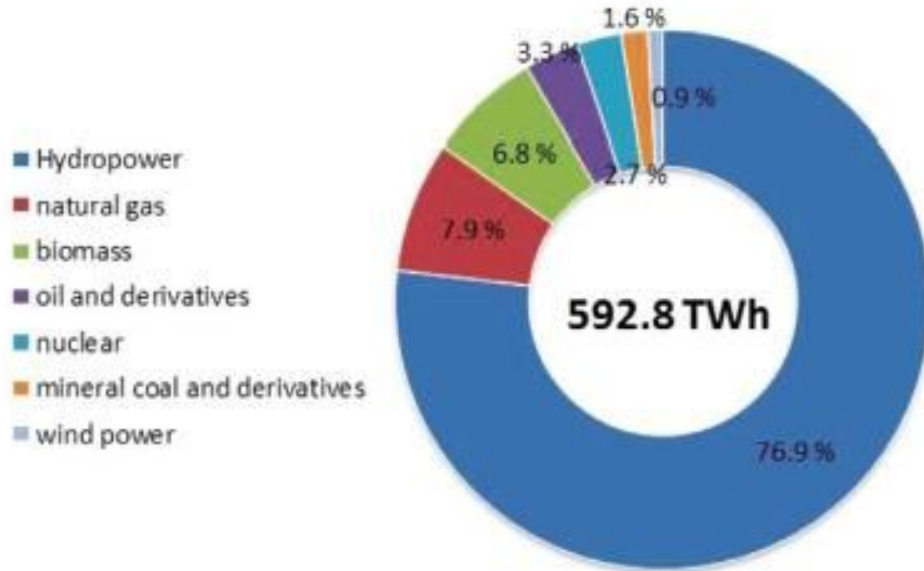


Energy Comparisons

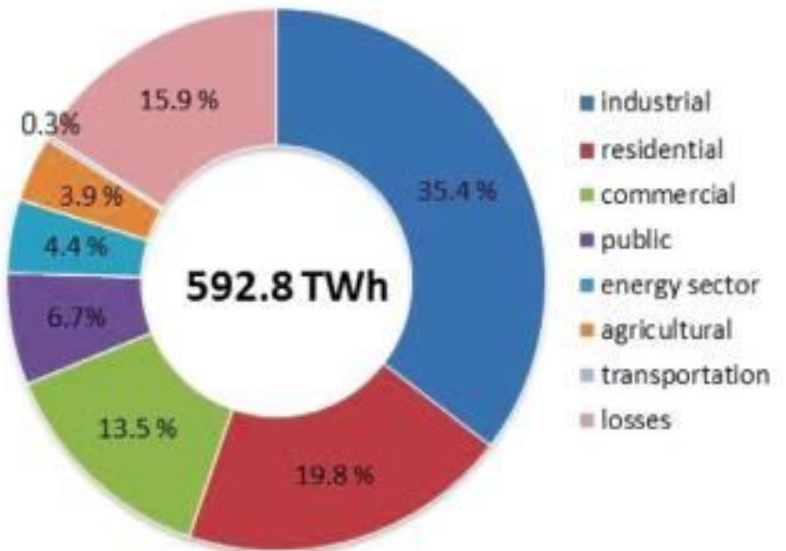
Type of Energy	Brazil	The World
Hydroelectricity	78.8%	16.6%
Other Renewables	6.6%	3.7%
Total Fossil Fuels	11.9%	66.6%
Nuclear	2.7%	13.0%

Brazil's Energy Production and Consumption

Electricity Generation



Electricity Consumption



Oil



Oil in Brazil

- Oil is a fossil fuel, formed from fossilized organic materials
- Technically but not practically renewable; takes millions of years to form
- Estimated that between $\frac{1}{5}$ - $\frac{1}{3}$ of potential energy in fossil fuels is usable and available
- In Brazil, oil is used to supply thermoelectric plants and to power vehicles alongside biofuels like Ethanol
- $\frac{1}{3}$ All crude oil processed in Latin America is done in Brazil
- Brazil exported 215,000 barrels/day in 2014, and was the second largest producer of petroleum in South America
- State controlled company Petrobras is dominant in the oil sector, tying oil into the health of the state economically

Pros of Oil-based Energy

- Relatively abundant
- Technologically available
- Power Plants already equipped to work with the material, requiring no new investment
- High energy density -- small amounts of oil produce relatively large quantities of energy
- Supports economic growth
- Currently reliable

Cons of Oil-based Energy

- Non-Renewable
- Use/Burning contributes to all 6 Criteria Air Pollutants, including high volumes of greenhouse gasses
- Contributes to Acid Rain and Climate Change
- Hazardous to drill for, hazardous if spilled
- Often contains carcinogenic additives and other toxins
- Dependent on a resource that is underground, limited, and must be harvested with specialized equipment
- Potential for drinking water contamination

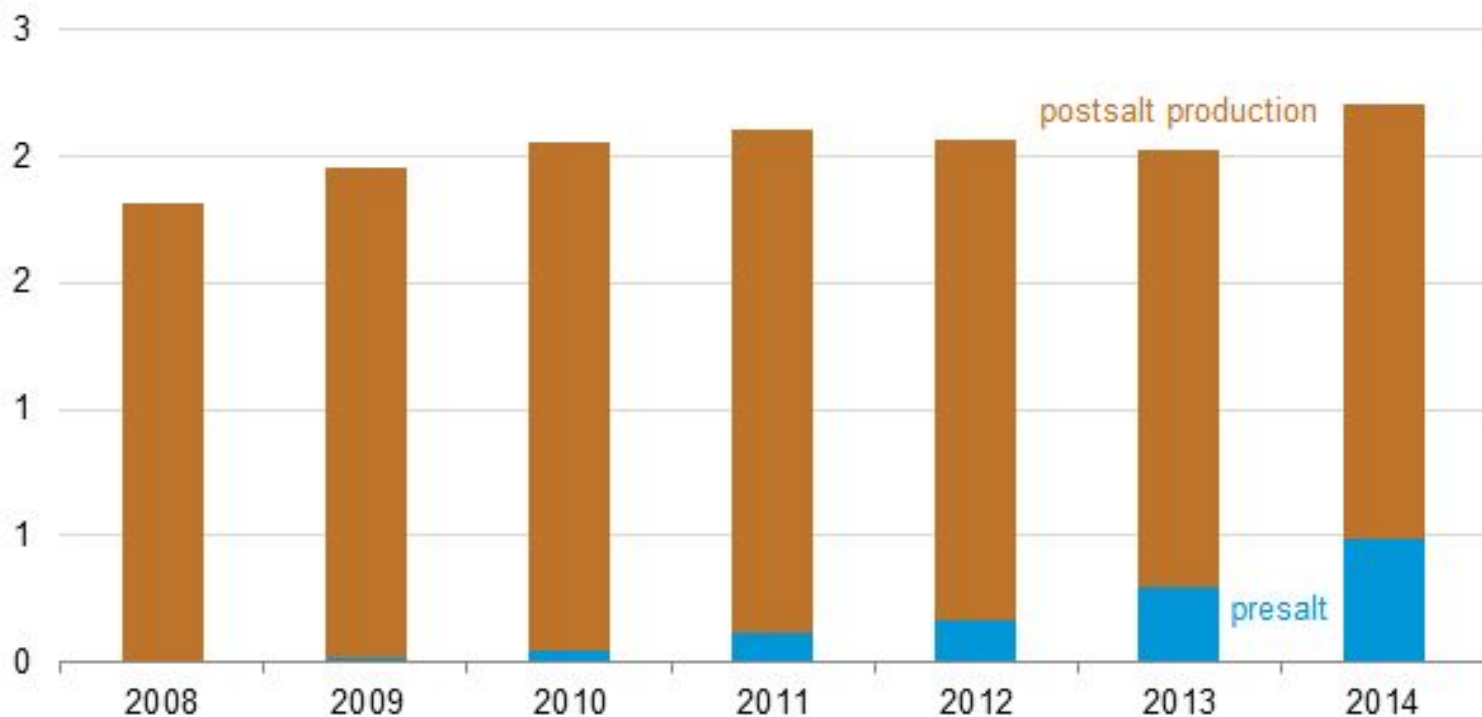
Pre-Sal Oil Fields Overview

- Found in 2007, 18,000 feet below ocean surface and beneath a layer of salt in the Santos Basin after oil was struck at the Tupi site
- The Pre-Sal fields are the largest discoveries in the past decade
- State's dominant stakes in the company Petrobras gives it effective control over the oil sector
- May 2014 yielded another pre-sal strike of an estimated 5 billion barrels
- Oil production rose from 41,000 b/d in 2010 to 1,000,000 b/d in 2016 increasing by a factor of 24x due to the pre-sal fields
- Has led to production of pioneering deep water drilling technologies
- Produces b/d greater than the industry average
- Has become a driving economic factor



Figure 3. Brazil oil production by type

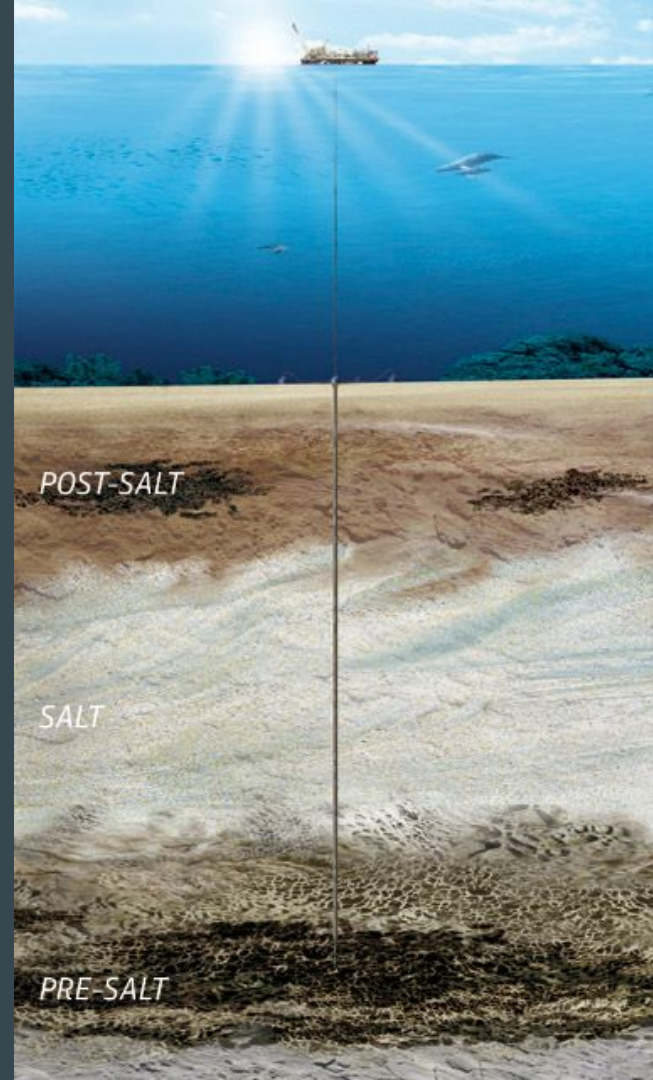
million barrels per day



Source: U.S. Energy Information Administration, Agência Nacional do Petróleo, Gás Natural e Biocombustíveis

Pre-Sal Geology & Geography

- Sequence of sedimentary rocks formed 100 million years ago during the separation of South America and Africa
- Large lakes formed at the site initially and filled with organic matter from nearly all the rivers surrounding the split
- Salt layer formed, covering this layer, as the Atlantic Ocean formed
- Salt layer is currently 2000m thick
- Area measures ~800km long by ~200km wide and ~300km off shore



\$4.45 vs. \$2.57

Average gas prices in Brazil versus in the United States, in USD/gallon.

Difference is due to Petrobras's market control, taxes, and a poor supply chain.

Sustainability?

Oil is non-renewable, often difficult to get to by conventional means, and is a serious pollutant along with other fossil fuels.

No.

It may be the most popular energy source globally right now, but it is a limited resource and bad for the environment -- and people. Consumption rate is significantly faster than harvesting rate.

Unless renewable, sustainable sources can be developed to replace it, we'll be in trouble once the crutch is pulled out from under us.

Biofuels



Biofuels in Brazil

- Sugarcane-sourced rather than Corn-sourced, making it more efficient than the US's corn-based ethanol
 - Doesn't drive up the price of foods
 - Sugarcane has become more profitable as fuel than as food
- Oil Embargo in the 1970's kickstarted Brazil's entry into the biofuel industry; previously 80% of their oil was imported
 - Brazil has become a global biofuel powerhouse

Biofuel Industry Developments

- Towns specialised all of their economic activity to center around sugarcane and the biofuel industry
- Industry in crisis due to very low petroleum prices, the lowest in 30 years
 - Ethanol is among hardest - hit sectors during economic slowing, with 3/7 of the major biofuel plants going bankrupt
 - Mechanization has cost the industry its high public support due to effect on the available jobs
- Gov't intervention to boost flex-fuel vehicles by incentivization has helped bolster the industry

Pros of Sugarcane-Ethanol Biofuels

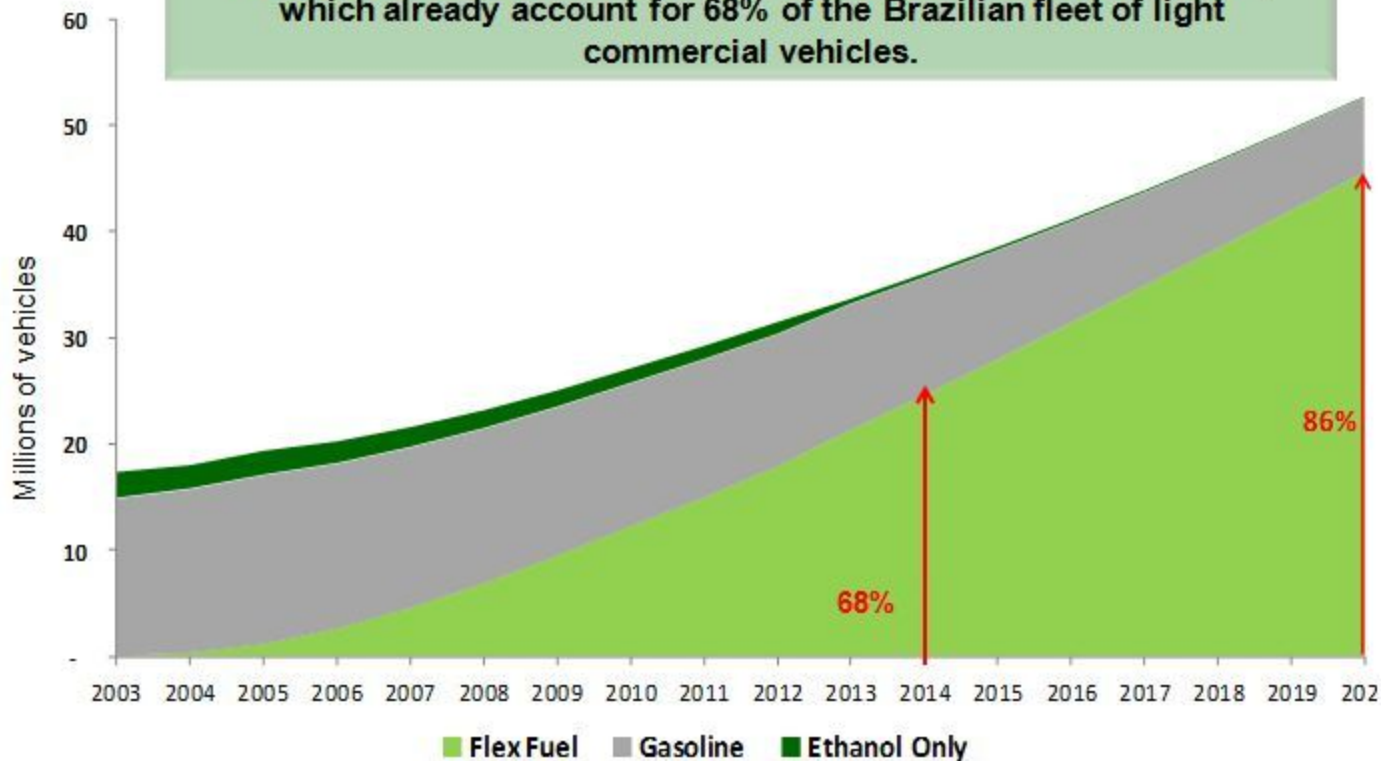
- Reduces air pollution from tailpipe emissions
- Produces only 20% as much greenhouse gas as conventional petroleum fuels
- Reduces petroleum use
- Potential to give Brazil a foothold in global markets
- Provides an affordable alternative fuel during oil price hikes

Cons of Sugarcane-Ethanol Biofuels

- Process uses Sucrose: waste fibers, Bagasse, contain $\frac{2}{3}$ of sugarcane's potential energy and liquid residue called Vanasse must be treated before disposal
- Technology to use these fibers is developing but prohibitively expensive
- Farming practices increase pesticide use and require more land
- Vulnerable to weather and climate changes; climatic requirements prevent it from becoming globally useful
- Exacerbates land rights and land inequality, occupying land that could produce food for the landless or be redistributed
- Distorts the land market by raising prices, preventing poor from acquiring farmland
- The sugar industry's profitability is dictated by the oil industry's prices

NATIONAL AUTOMOBILE AND LIGHT VEHICLE FLEET

Today, 16 automakers offer over 242 models of flex fuel vehicles, which already account for 68% of the Brazilian fleet of light commercial vehicles.



Brazilian Flex-Fuel Fleet

- 40% of gasoline needs have been replaced with sugarcane ethanol
- Most ethanol is consumed by the domestic market either pure or in a mixture with gasoline
- Flex-Fuel Vehicles, introduced in 2003, greatly increased the popularity of ethanol
- >90% of new cars sold are FFV, and 60% of the total fleet are FFV, with the remainder operating on only gasoline and expected to be mostly imports
- Sao Paulo is on the cutting edge of ethanol use for public transportation fleets
- Market infrastructure includes pumps with fuel options to accommodate different types of cars and to allow for consumers to choose their fuel during price fluctuations
- Mandatory 27.5% ethanol minimum in petrol fuels

Sugarcane Vs. Corn Based Ethanols

- Corn starches must be converted to sugar before distillation
- 50% of the dry mass can be used for fuel
- Sugarcane requires no conversion, reducing processing costs
- All of the sugarcane can potentially produce energy
- One acre of sugarcane produces more ethanol on average than one of corn

Sugarcane's energy balance is seven times greater than corn's.

Estimated cost of corn and sugarcane ethanol in the US and Brazil (2007).

Source: Authors' calculations based on primary data. Sources of primary data are discussed in Section 3.

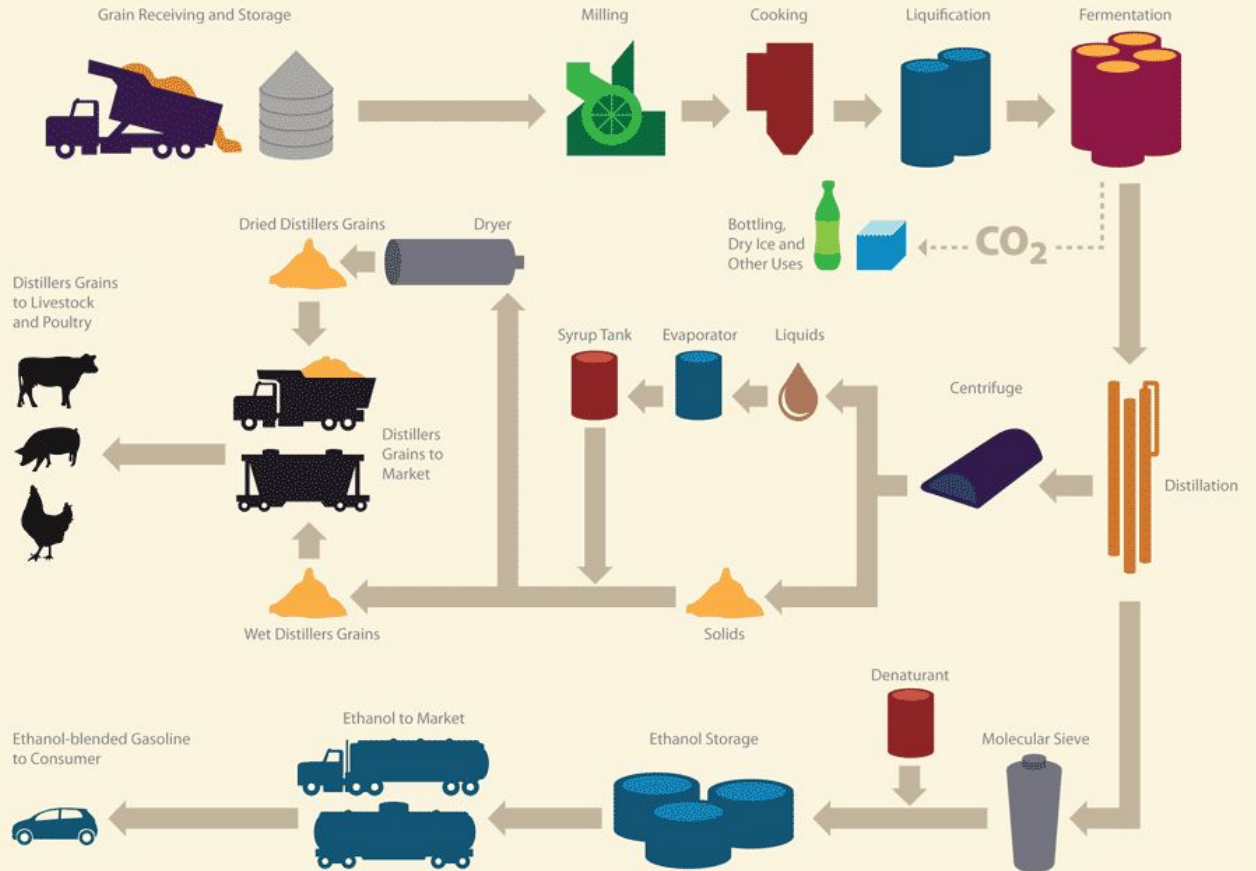
Cost items (per ha)	Feedstock				Corn US\$
	Sugarcane			US\$	
	RS	US\$	US\$		
	US\$1 = RS1.55	US\$1 = RS2.15	US\$1 = RS2.62		
Fertilizers	546.1	352.3	254.0	208.4	226.2
Nitrogen					134.2
Phosphorous					52.2
Potassium					29.9
Lime					9.9
Chemicals	222.9	143.8	103.7	85.1	106.3
Seed	144.7	93.3	67.3	55.2	110.8
Machinery, repairs, fuel, and hire	1475.8	952.1	686.4	563.3	217.4
Transportation to refinery	502.5	324.2	233.7	191.8	37.4
Total operating cost per ha (a)	2892	1866	1345	1104	698
Total operating cost per m³	470	300	220	180	170
Return to land and management (b)	182.0	117.4	84.7	69.5	745.4
Total feedstock cost per ha (a+b)	3074	1983	1430	1173	1443
Feedstock cost per m³	500	320	230	190	340
Refinery costs per m³ (c)	360	230	170	140	190
Inputs	300	200	140	120	160
Depreciation	60	40	30	20	30
Total domestic cost (a+b+c)	860	550	400	330	530
Transport from refinery to US Port (d)	179	120	80	70	N/A
(Co-product credit per m ³ of ethanol)	0	0	0	0	-120
Total cost per m³ of ethanol (a+b+c+d)	1039	670	490	400	410

U.S. Ethanol Production by Technology Type



Source: U.S. Dept. of Agriculture

DRY MILL ETHANOL PROCESS





Sugarcane (120 lbs)



Juice extraction



Cane juice



Bagasse (31 lbs)



S. cerevisiae



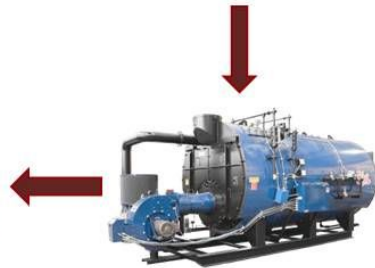
Fermentation



CO₂
(6-12 lbs)



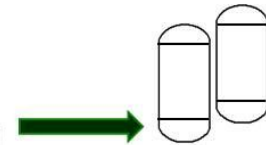
Heat/Steam/
Electricity generation



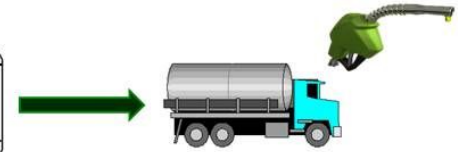
Boiler



Distillation



Molecular sieves



Anhydrous ethanol
(1 gal)



Vinasse
(8-15 gals)

Sustainability?

Biofuels are often ineffective and inefficient, such as with corn-based ethanol in the US, but where conditions are right it can be a valuable resource.

Yes... but with some limitations:

Politically, the production of biofuels is dubious given the imbalances in Brazil's land ownership.

Environmentally, the farming practices used to produce the monocultures can be problematic or toxic.

Technologically, we have a way to go before using the whole product is cost effective.

Globally, the usefulness of this fuel depends greatly on climate and economic impacts.

Wind



Wind Energy in Brazil

- Often overlooked in favor of oil along the coast
- First wind generator went into operation in 1992, but stagnated until the drought in 2001 that bottlenecked the hydropower plants
- Part of the incentive program for alternate energy sources, PROINFA, which established the industry and provided technology and jobs
- Capacity of 6.5 GW, the third main energy source after biomass and hydro
- Northeast is most productive due to uninhabited flatlands couple with high winds
- Was expected to have the 7th highest installed capacity by the end of 2015

Pros of Wind Energy

- Reduces CO2 emissions by 11,600,000 tons
- Production does not involve harmful chemicals or emissions
- Renewable resource
- Production costs are falling

Cons of Wind Energy

- Turbines tend to operate at ~30% capacity
- Severe storms or winds can damage turbines
- Blades of turbines can be hazardous to wildlife (birds, bats)
- Turbines have been known to interfere with signal reception for electronics
- Wind is intermittent
- Cost competitiveness is questionable
- Requires open land in areas of high wind speeds, often remote

Sustainability?

In a country such as Brazil that has both land to place turbines and frequent high winds, there isn't much question.

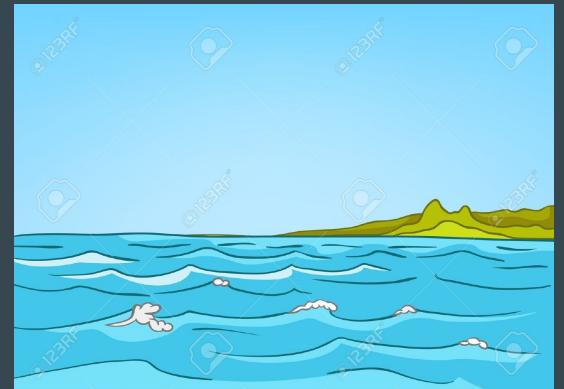
Yes!

Although wind may not be capable of becoming the main source of power, its contributions and benefits can't be discounted, and it can make up for limitations in other kinds of alternate energy.





Hydroelectric



Hydroelectricity in Brazil

- Hydroelectricity is electricity that is made by the movement of water. It is usually harnessed through dams that block a river to form a reservoir and collect water. Once the water is released, the vast pressure behind the dam forces the water down pipes that lead to a turbine. This water forces the turbine to spin, causing a generator to turn and harness the energy potential from the water in the form of electricity.
- Hydroelectricity is the source of upwards of 70% of the energy used in Brazil today.
- Currently Brazil's hosts 44 hydroelectric dams, and is home to Itaipu dam, which at one time was the world leader in electricity production.

Hydroelectric Influence: Brazil: 78.8% The World: 16.6%

Pros and Cons of Hydroelectricity

Pros

- Produces vast amount of renewable energy (70%)
- Creates jobs (construction, design, operations)
- Inexpensive electricity (0.85 cents per KWh)
- Renewable energy source

Cons

- Flooding of occupied regions
- Displacement of residents and destruction of ecosystems
- Habitat loss (Pink River Dolphin)
- Possible water pollution

Itaipu Dam

In 1984, Itaipu dam began harnessing the energy of the Parana River.

It has a potential of 14GW.

In 2013 the plant generated a record 98.6TWh, providing 75% of the energy consumed by Paraguay and 17% of the energy consumed by Brazil.



Dams Across the Nation

Rank	Plant/Dam	River	State	Capacity
1	Itaipu	Paraná	Paraná	14,000 MW
2	Belo Monte	Xingu	Pará	11,233 MW
	São Luiz dos			
3	Tapajós	Tapajós	Pará	8,381 MW
4	Tucuruí	Tocantins	Pará	8,370 MW
5	Ilha Solteira	Paraná	São Paulo	3,444 MW
6	Jirau	Madeira	Rondônia	3,300 MW
			Alagoas and	
7	Xingó	São Francisco	Sergipe	3,162 MW
8	Santo Antônio	Madeira	Rondônia	3,150 MW
9	Paulo Afonso IV	São Francisco	Bahia	2,462 MW
10	Jatobá	Tapajós	Pará	2,338 MW

Environmental Impacts of Hydroelectric Dams

- Habitat/Land loss
- Flooding/Drought
- Increased sediment
- Algae blooms
- Erosion/ Weakened soils
- Disrupted wildlife migration patterns
- Fragmented habitats and territories or wildlife
- Increased CO₂ emissions (up to 0.5 lbs per KWh)

Sustainability?

Hydroelectric is no doubt a renewable energy source, but is it truly sustainable? And at what cost?

Residents are forced from their homelands after they become flooded by the reservoirs created by the dams.

Entire ecosystems, become destroyed and flooded killing off the flora and either killing or forcing out the fauna.

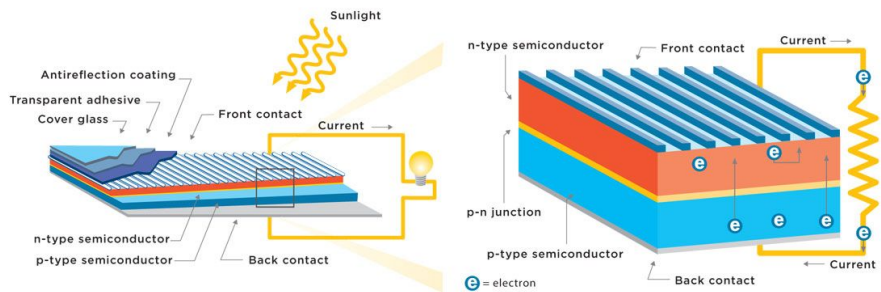
Pink River Dolphins, and endangered species, are losing valuable habitat through fragmented rivers caused by dams.

Solar



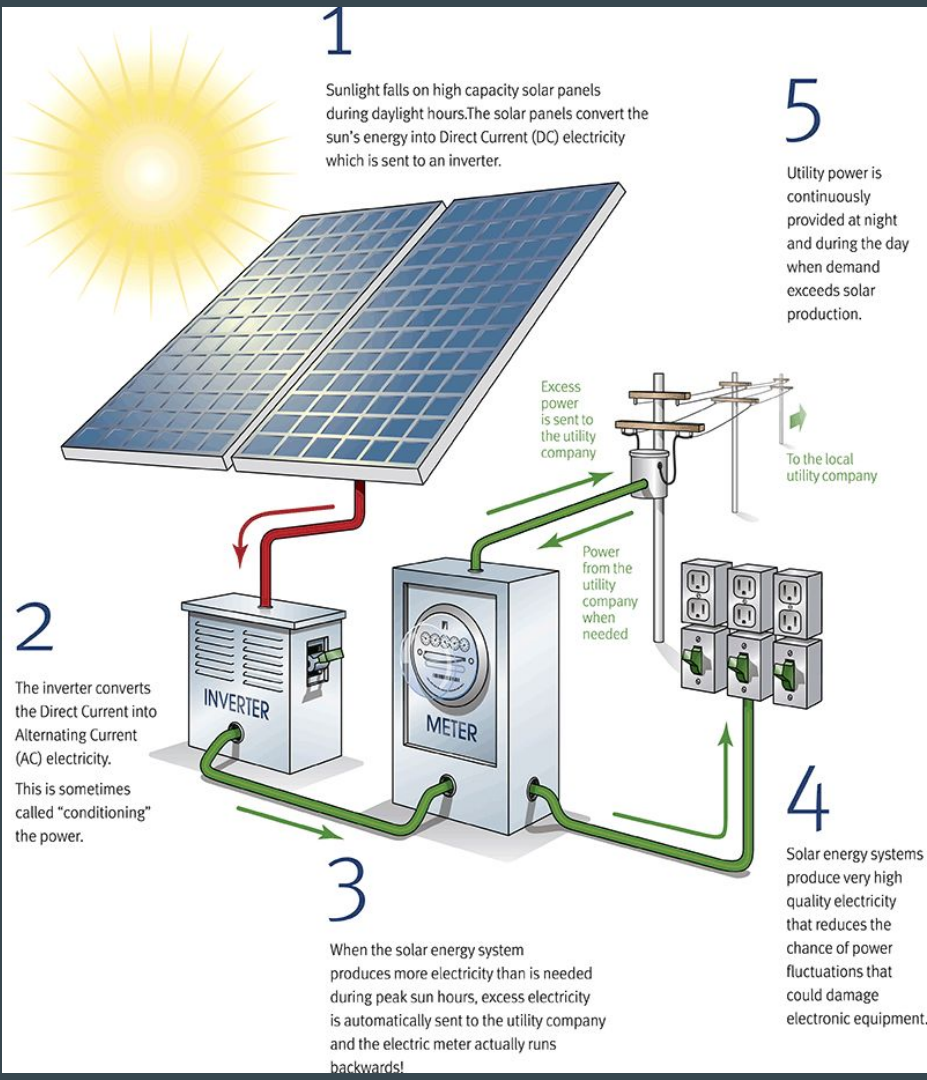
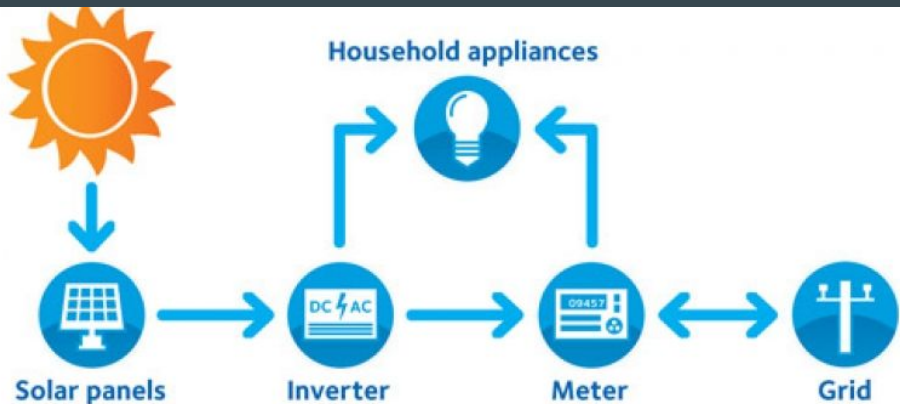
Solar in Brazil

- Solar electricity generation represents a clean alternative to electricity from fossil fuels, with no air and water pollution, no global warming pollution, no risks of electricity price spikes, and no threats to our public health.
- Solar photovoltaic panels convert the sun's energy to direct current (DC) electricity, this energy is converted to alternating current (AC) through an inverter, at this point, the electricity usable and transferable.
- Brazil has one of the highest solar energy potential, 4.25 to 6.5 hours a day of peak sun.
- Currently there are only 1300 grid connected solar facilities in Brazil



Solar cells are composed of two layers of semiconductor material with opposite charges. Sunlight hitting the surface of a cell knocks electrons loose, which then travel through a circuit from one layer to the other, providing a flow of electricity.

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Solar Auctions in Brazil

- In Brazil's “reverse” power auction mechanism, the government sets a maximum price for the megawatt-hour (MWh) and energy companies bid down the price to the lowest rate which they are willing to sell energy to the public. Companies that bid the lowest price, often sign a 20-year power purchase agreement with distribution companies, which are mandated to purchase power via the auctions, driving the cycle.
- Three solar power auctions have been held to date (December 2015). The auctions secured approximately R\$ 12 billion (\$3 billion USD) in investments for the next three years and attracted a number of domestic and international players into the solar energy market.
- Brazil plans to boost the number of grid connected solar plants from 1,300 at the end of 2015 to approximately 1.2 million by 2024.

Pros and Cons of Solar

Pros

Most renewable resource

No pollution/Clean energy

Less expensive than fossil fuels

Little to no environmental impacts

Cons

Expensive installment

More expensive than hydroelectricity (12.2 cents per KWh)

Uses a vast open area, taking up valuable space for agriculture

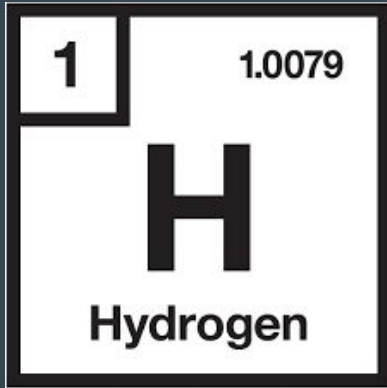
Sustainability?

Solar is no doubt a renewable energy source, but is it sustainable? And at what cost?

Yes with minimal impacts!

Solar is clean, efficient, and the most renewable energy source!

Yes, it may take away a few fields from farmers trying to graze their cattle, but the benefits outway the costs



Hydrogen



Hydrogen in Brazil

- Hydrogen is the simplest element. An atom of hydrogen consists of only one proton and one electron. It's also the most plentiful element in the universe.
- In order for hydrogen to be used as a fuel it must undergo a chemical reaction.
- A fuel cell combines hydrogen and oxygen to produce electricity, heat, and water. Fuel cells are often compared to batteries. Both convert the energy produced by a chemical reaction into usable electric power. However, the fuel cell will produce electricity as long as hydrogen is supplied, never losing its charge.
- There is virtually no pollution, the only byproduct is pure, drinkable water.

Hydrogen Bus Project

- Brazil's Ministry of Mines and Energy and São Paulo Metropolitan Urban Transport Company have officially launched the country's first hydrogen fuel-cell bus project, in partnership with the United Nations Development Program, the Global Environment Facility, and the Projects Funding Body.
- The \$16-million project consists of the purchase, operation, and maintenance of five hydrogen powered passenger busses, a station for hydrogen production, and fuel supply for the buses. These new busses will be used in São Paulo for four years and are expected start running in the experimental phase next year (2006).
- On March 20th, 2016 two busses were finally implemented into service in São Bernardo do Campo.

Pros and Cons of Hydrogen

Pros:

- No pollution
- Creates pure drinkable water
- Fuel cells will never lose charge as long as fuel is present



Cons:

- Inefficient conversion of electricity (15% to 35%)
- Dangerous/ Explosive
- Expensive
- Utilizes other resources to create (renewable and fossil fuels)

Sustainability?

Hydrogen is considered a renewable resource, but is it sustainable? And at what cost?

In order to create hydrogen as a fuel, it is needed to force water to undergo electrolysis or it is needed to burn fossil fuels. This seems counter productive.

Hydrogen can be a valuable tool, but not a sustainable one.

To create a resource , you must exploit others is not a sustainable practice, especially if the exploited resources can create energy more easily and efficiently.

Overall, a

NO.

Where will Brazil be in ten years?

References I

- Contributor, G. (2016). Brazil Doubles 2024 Solar Power Target. Retrieved January 01, 2017, from <https://cleantechnica.com/2016/01/14/brazil-doubles-2024-solar-power-targe>
- Duran, R. (2015). Hydro Electricity in Brazil. Retrieved January 01, 2017, from <http://thebrazilbusiness.com/article/hydro-electricity-in-brazil>
- Enel. (2016). ENEL STARTS CONSTRUCTION OF NEW 103 MW SOLAR PLANT IN BRAZIL. Retrieved January 01, 2017, from <https://www.enel.com/en/media/press/d201609-enel-starts-construction-of-new-103-mw-solar-plant-in-brazil.html>
- Figueiredo, R. (2016). Retrieved January 01, 2017, from <http://www.renewableenergyworld.com/articles/2016/02/new-developments-in-brazil-s-solar-power-sector.html>
- Media, B. (2006). Green Car Congress: Brazil Launches Hydrogen Fuel-Cell Bus Project. Retrieved January 01, 2017, from http://www.greencarcongress.com/2006/11/brazil_launches.html
- Ministry of Mines and Energy. (2005). *CURRENT STATUS OF HYDROGEN ENERGY DEVELOPMENT IN BRAZIL* [PDF].
- Von Sperling, E. (2012). Hydropower in Brazil: Overview of Positive and Negative Environmental Aspects. Retrieved January 01, 2017, from <http://www.sciencedirect.com/science/article/pii/S187661021200793X>

References II

- Wesleyan Economics Students . (2012, May 18). Sugarcane vs. Corn Based Ethanol. Retrieved January 06, 2017, from <https://biowesleyan.wordpress.com/first-generation-biofuels/ethanol/case-study-brazil/sugarcane-vs-corn-based-ethanol/>
- Rapoza, K. (2016, September 26). Brazil's Crazy Gasoline Prices Will Keep Petrobras Investors Happy. Retrieved January 06, 2017, from <http://www.forbes.com/sites/kenrapoza/2016/09/26/petrobras-to-keep-the-screws-tight-on-brazil-gasoline-no-price-cuts/#49eb73394433>
- About Sugarcane. (n.d.). Retrieved January 06, 2017, from <http://sugarcane.org/sugarcane-products/ethanol>
- Kutas, G. (2013, February). Biofuels in South America and Central America. Retrieved January 06, 2017, from http://www.biofuelstp.eu/s_america.html
- Pre-Salt: Oil Exploration and Production. (n.d.). Retrieved January 06, 2017, from <http://www.petrobras.com.br/en/our-activities/performance-areas/oil-and-gas-exploration-and-production/pre-salt/>
- Bioenergy Research Group. (n.d.). Sugarcane Ethanol. Retrieved January 06, 2017, from <http://www2.hawaii.edu/~khanal/fungal/sugarcaneethanol.html>
- Brazil Gasoline prices, liter. (n.d.). Retrieved January 06, 2017, from http://www.globalpetrolprices.com/Brazil/gasoline_prices/