September 22, 2022 – Task 64

Technology Collaboration Programme on Advanced Motor Fuels

E-fuels

Availability of resources Brazilian overview

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General Overview |Brazil at a Glance

Technology Collaboration Programme on Advanced Motor Fuels

Territory

8.516 mil km²

Rússia 17,1 mi km²

Estados Unidos 9,834 mi km²

Canada 9,984 mil km²

China 9,597 mi km²

215 million people (7th largest population)

1.609 Trillion USD GDP 2021 (13th largest economy)

8th Largest Oil Consumer (BP Statistical Review 2022)

19 Refineries

2.4 Million bpd Refining Capacity

9th Largest Refining Capacity (BP Statistical Review 2022)

62 Billion liters of Diesel (with 10% to 13% of biodiesel), consumed in 2021

39 Billion liters of Gasoline B (with 27% of ethanol), consumed in 2021

13 Billion liters of LPG consumed in 2021

Brazil is among the **10 largest** crude oil producers and exporters in the world

Brazil is taking a leading role in the E&P Sector

2022

Production:

- 3 Million bpd of oil production (Apr 2022)
- 137 Million m³/d of gas production (Apr 2022)

Reserves:

- 13.2B Bbl in proved oil reserves (Dec 2021)
- 379B M³ in proved gas reserves (Dec 2021)

- 83 E&P company groups, ~50% foreign (Sep 2022)
- 1.32 Million bpd of crude oil export (2021 Average)

Forecast

Potential to reach more than

4 Million bpd of oil in 2025 (PAP 2022)

5 Million bpd of oil in 2030 (EPE)

Potential to be the

5th Largest crude oil exporter in 2030 (EPE)

Source: ANP (2022). Available in: https://www.gov.br/anp/pt-br/assuntos/investments-opportunities-in-brazil

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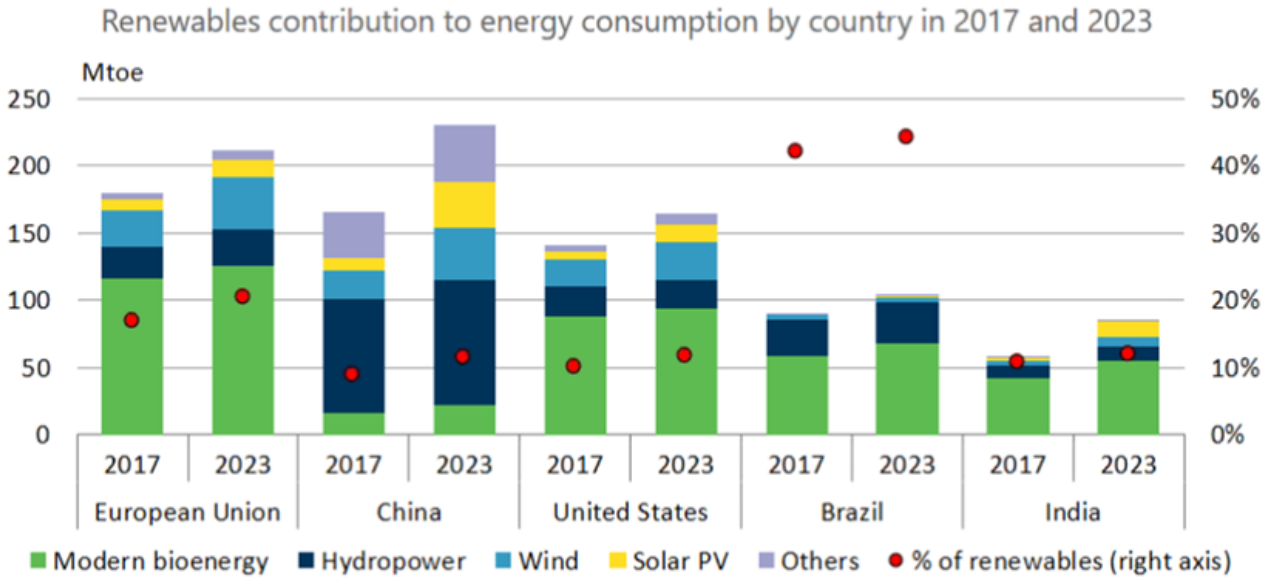
MINISTÉRIO DE MINAS E ENERGIA

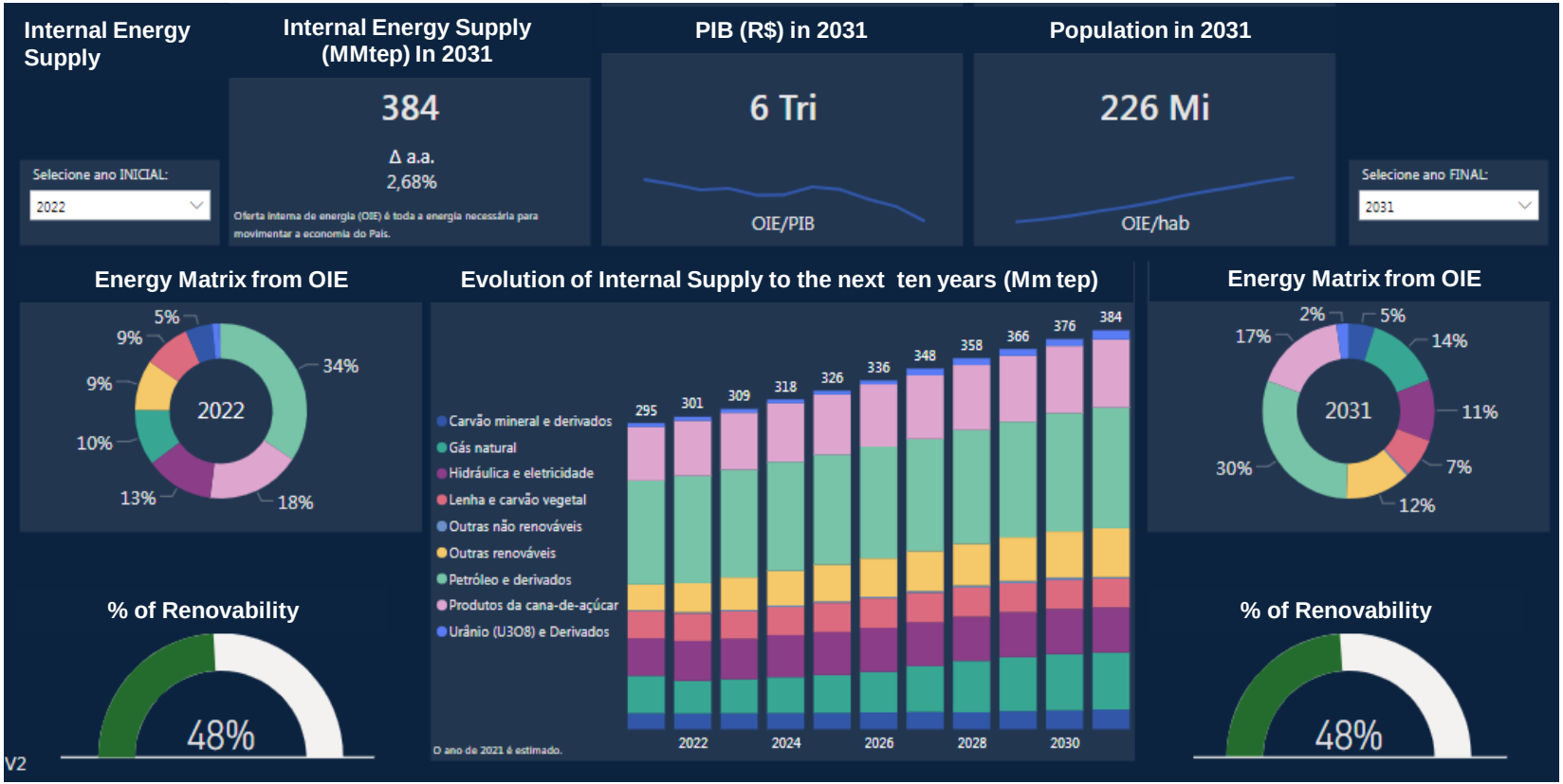
General Overview |Brazilian Energy Sector

The Brazilian energy sector is today one of the most renewable regarding the main great economies. Such differential should be maintained as a geopolitical asset, although it does not necessarily ensure a proper transition.
Brazil is a global leader in biotechnology and bioenergy.



Source: IEA (2018)

PDE 2031|Brazilian Energy Sector



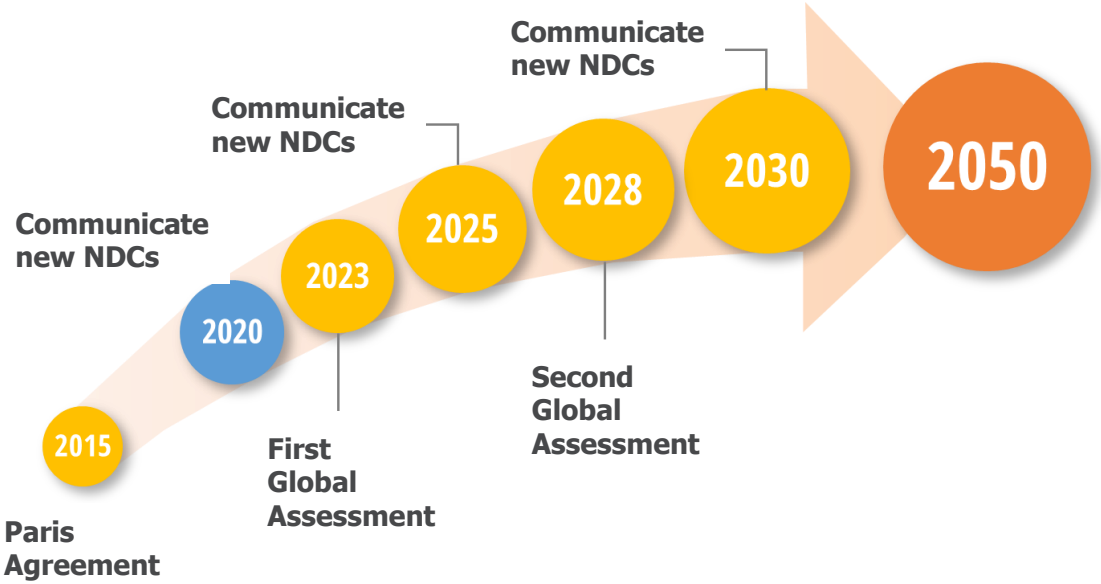
Source: EPE (2022). Available in: https://www.epe.gov.br/pt/publicacoes-dados-abertos/publicacoes/plano-decenal-de-expansao-de-energia-2031

Energy Transition and Decarbonization

Technology Collaboration Programme on Advanced Motor Fuels

Energy Systems should follow a pathway for reduction in carbon intensity, in an energy transition with strong competition between the different sources.

The climate agenda will influence the commercial and international affairs.



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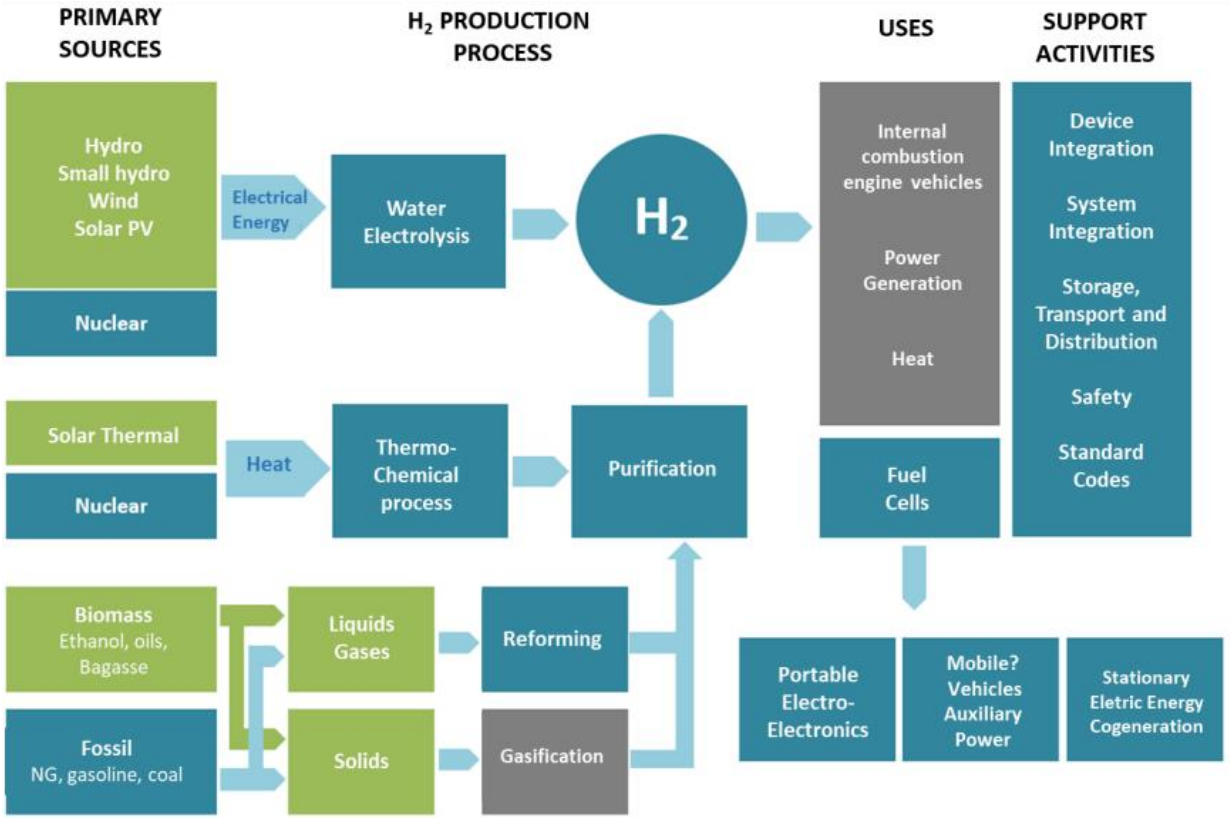
MINISTÉRIO DE MINAS E ENERGIA

Hydrogen Technologies



Source: Based on CGEE (2010)

Hydrogen in Energy Sector Planning

Source: https://www.epe.gov.br/pt/publicacoes-dados-abertos/publicacoes/plano-decenal-de-expansao-de-energia-2031

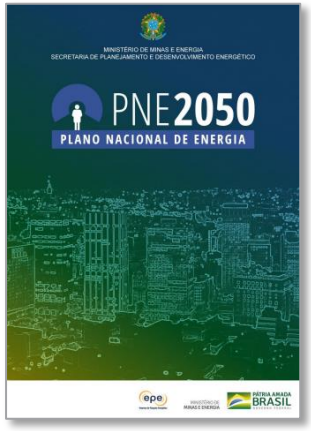
Chapter 12 – Hydrogen

- Hydrogen role in energy transition and descarbonization;
- Brazilian policies (P&DI, Programs and studies);
- CNPE Resolutions;
- Technical Production Potential; Projects

Hydrogen in EPE studies

Hydrogen in PNE 2050

- ❑ Hydrogen can be a disruptive technology
- ❑ It will be relevant in the context of:
  - ✓ energetic matrix decarbonization
  - ✓ insertion of distributed energy resources
  - ✓ storage and flexibility strategies



Source: https://www.energy.gov/eere/fuelcells/h2scale

Transport sector

- ❑ Technological perspectives for electric vehicles using fuel cell
- ❑ Hydrogen from liquid biofuels, fossil methane or biomethane

Energy Policies recomendations

- ❑ Decarbonization of setors such as industry, transport, energy
- ❑ Improve regulation, incentive and use of new technologies

Hydrogen mixed in natural gas

- ❑ Transport and storage
- ❑ Better use of infrastructure
- ❑ Offer importante volumes for energetic uses
- ❑ Limited pressure and percentage

EPE and Hydrogen - Technical Notes (PDE 2031)

- Black Hydrogen – black coal gasification
- Grey Hydrogen – methane steam reforming
- Brown Hydrogen – brown coal (lignite) gasification
- Blue Hydrogen - methane steam reforming, with CCUS
- Green Hydrogen – renewable electricity water electrolysis (mainly wind and solar)
- White Hydrogen – natural or geological hydrogen extraction
- Turquise Hydrogen – methane pyrolysis without CO_2
- Moss Green Hydrogen – biomass or biofuels reforming, gasification or anaerobic digestion, with or without CCUS
- Pink Hydrogen – water electrolysis from nuclear power
- Yellow Hydrogen – water electrolysis from mixed-origin grid energy

The studies about Blue, Gray and Turquoise Hydrogen were elaborated through a technical cooperation between EPE and BEP (Brazilian Energy Program) supported by the British government.

Source:

https://www.epe.gov.br/pt/publicacoes-dados-abertos/publicacoes/nota-tecnica-bases-para-a-consolidacao-da-estrategia-brasileira-do-hidrogenio
https://www.epe.gov.br/pt/publicacoes-dados-abertos/publicacoes/nota-tecnica-sobre-hidrogenio-turquesa
https://www.epe.gov.br/pt/publicacoes-dados-abertos/publicacoes/notas-tecnicas-dedicadas-ao-hidrogenio-cinza-e-ao-hidrogenio-azul
https://www.epe.gov.br/pt/publicacoes-dados-abertos/publicacoes/nota-tecnica-producao-e-consumo-de-hidrogenio-em-refinarias-no-brasil

Brazilian Hydrogen Program – PNH_2

Guidelines:

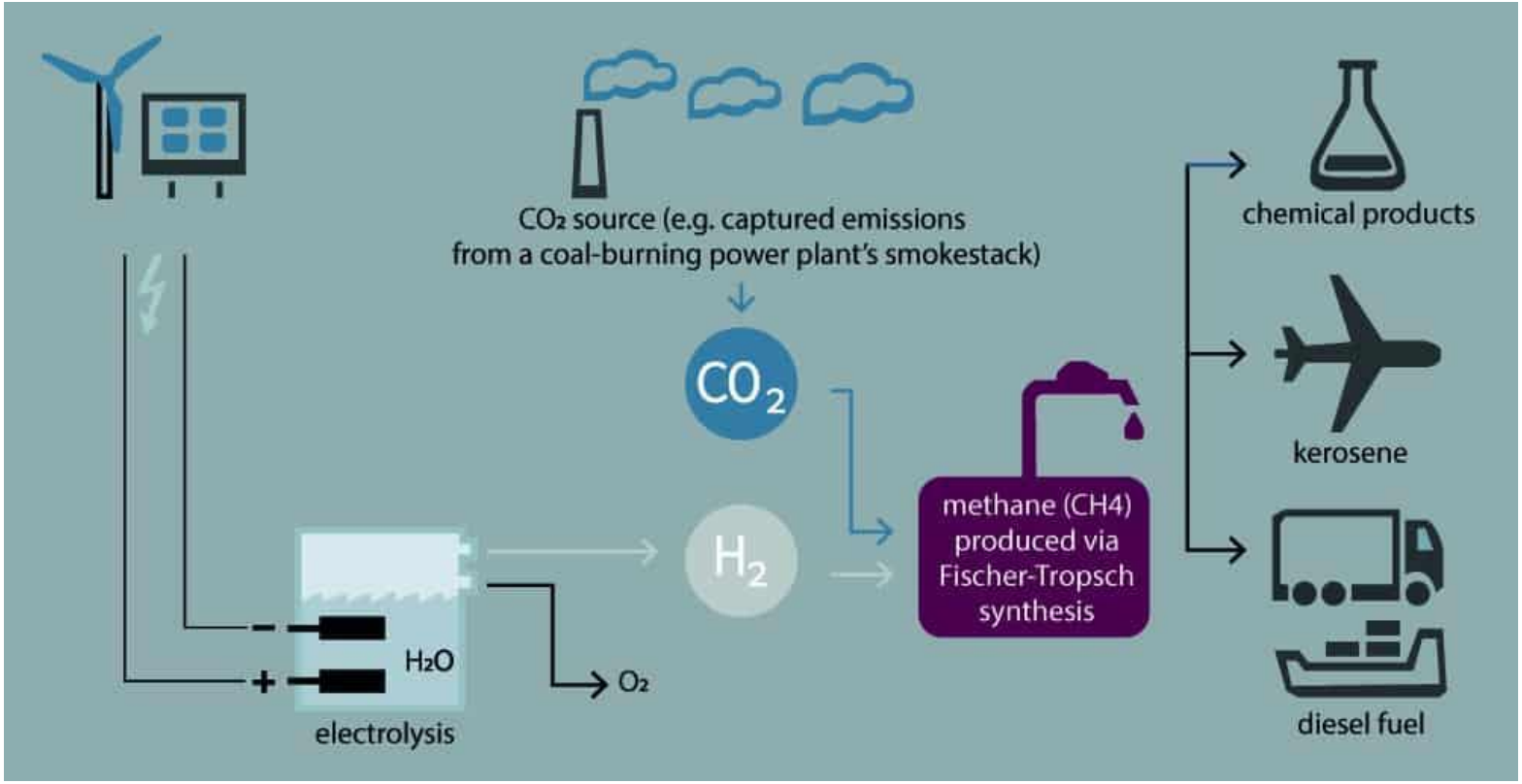
- Develop and study the hydrogen market in Brazil and the country's international insertion in economical and competitive basis
- Contributions for a low-carbon energy matrix
- Diversity of applications for hydrogen in Brazilian economy
- Brazilian leadership in the theme "Energetic Transition" at **High Level Dialogues on Energy** from United Nations

CNPE Resolution nº 6, 04/20/2021
Determine to Ministries (MME, MCTI and MDR) cooperation with EPE's technical support, to propose Guidelines for PNH_2.

PNH_2 (08/04/2021)
Proposed by public entities, private atakeholders and Academy, to promove and create a competitive Hydrogen market.

Source: https://www.gov.br/mme/pt-br/assuntos/noticias/mme-apresenta-ao-cnpe-proposta-de-diretrizes-para-o-programa-nacional-do-hidrogenio-pnh2/HidrognioRelatriodiretrizes.pdf

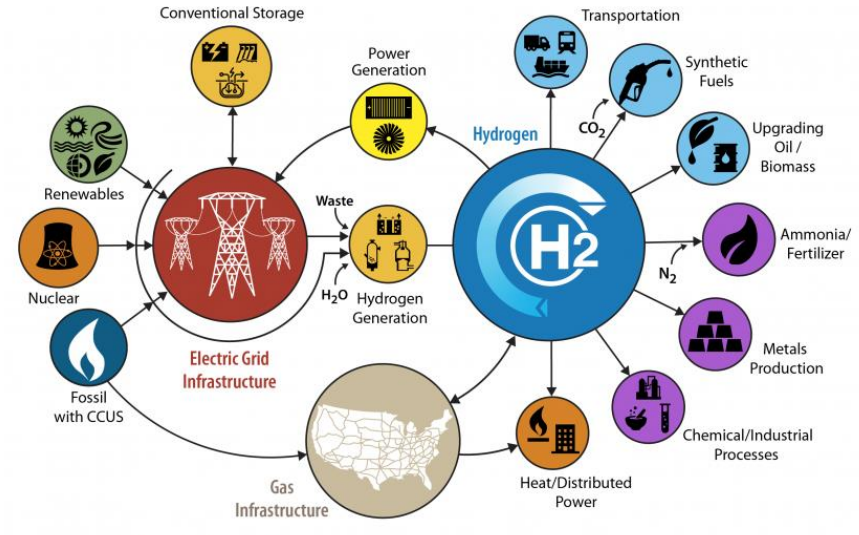
Resources



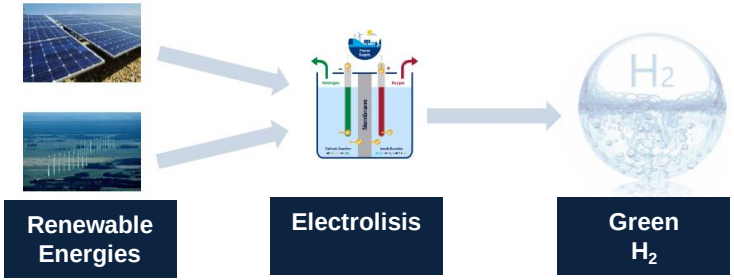
Resources

Source: https://as-schneider.blog/2022/03/02/what-are-power-to-x-solutions/

Hydrogen Technologies



Source: https://www.energy.gov/eere/fuelcells/h2scale



National Hydrogen Program (CNPE Resolution Nr. 6/2021)

Guidelines

- Develop and study the hydrogen Market in Brazil and the country's international insertion in economical and competitive basis
- Contributions for a low-carbon energy matrix
- Diversity of applications for hydrogen in Brazilian economy

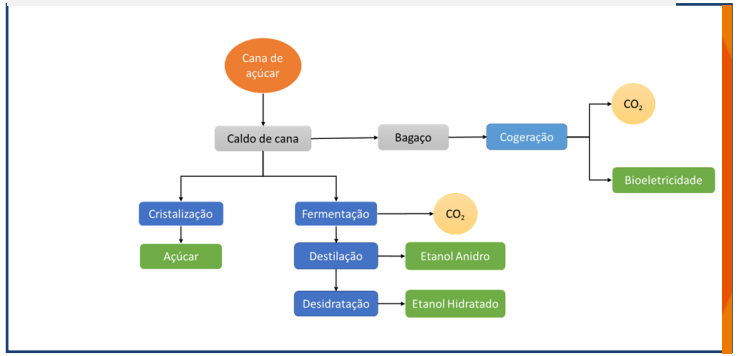
Obtaining CO/CO_2 in the ethanol and biodiesel production

Fischer-Tropsch Process : Synthesis gas and catalysis

Ethanol

The broth fermentation process gives rise to a flow of CO_2.

Figure 1 – CO_2 sources in the ethanol production

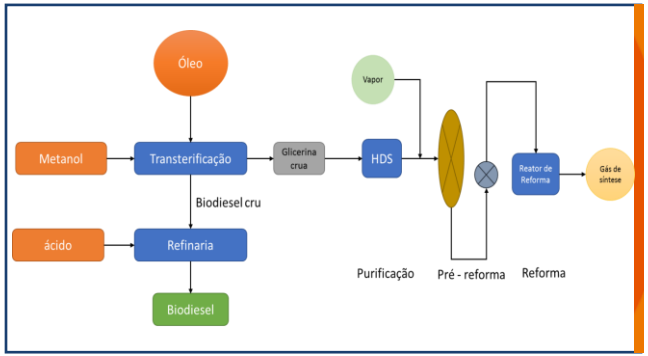


Source: own elaboration, based in DIAS *et al* (2015).

Biodiesel

Ester-based biodiesel has glycerin as a co-product, which can give rise to synthesis gas.

Figure 2-Obtaining synthesis gas in the biodiesel production



Source: own elaboration, based in HERMES (2010).

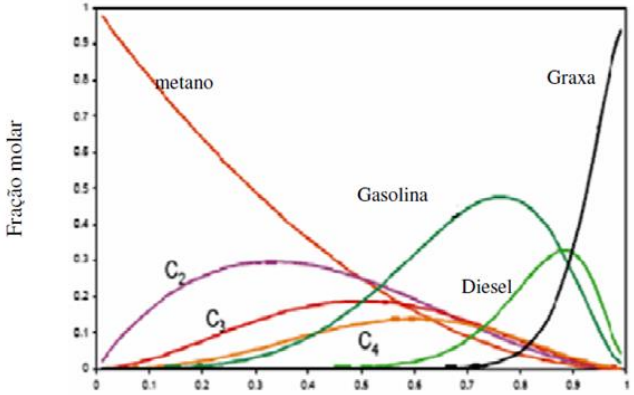
Steam reforming, aqueous phase reforming, partial oxidation, gasification and supercritical water gasification and more recently developed and adopted methods such as dry reforming, pyrolysis, thermal arc plasma or microwave plasma gasification and co-gasification.

Biofuels of synthesis origin

- The process of generating synthesis gas occurs through the conversion of a hydrocarbon under the action of a gaseous oxidant, which can be purified O_2, O_2, enriched air, air, steam, carbon dioxide and combinations.
- Requires high purity CO_2
- H_2 that can be obtained through electrolysis

- The conversion of synthesis gas into hydrocarbons through the Fischer-Tropsch process can occur in wide temperature range. According to the process conditions, which include pressure, temperature, gas composition, catalyst and reactor types, the conversion may give rise to analogues to diesel, naphtha, gasoline or alpha-olefins.

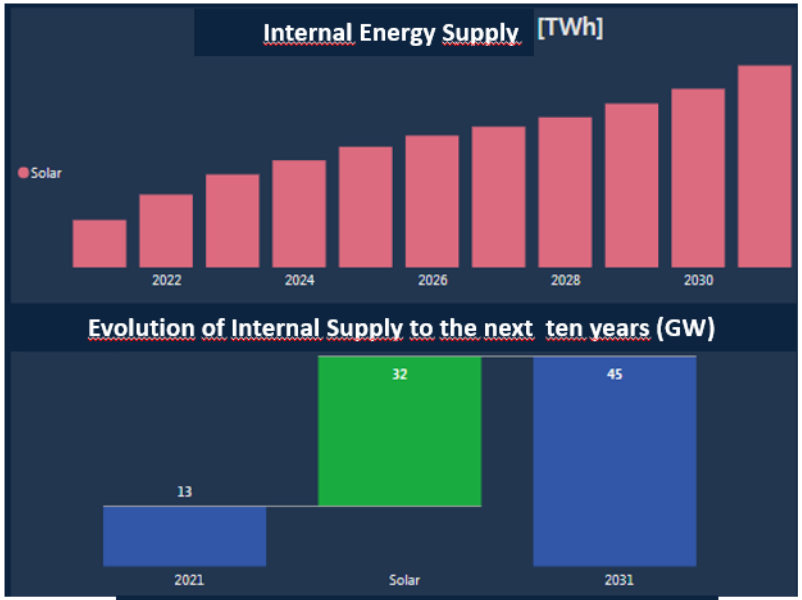
Figure 3 – Distribuition of hydrocarbons as a function of the probability of chain growth (α)



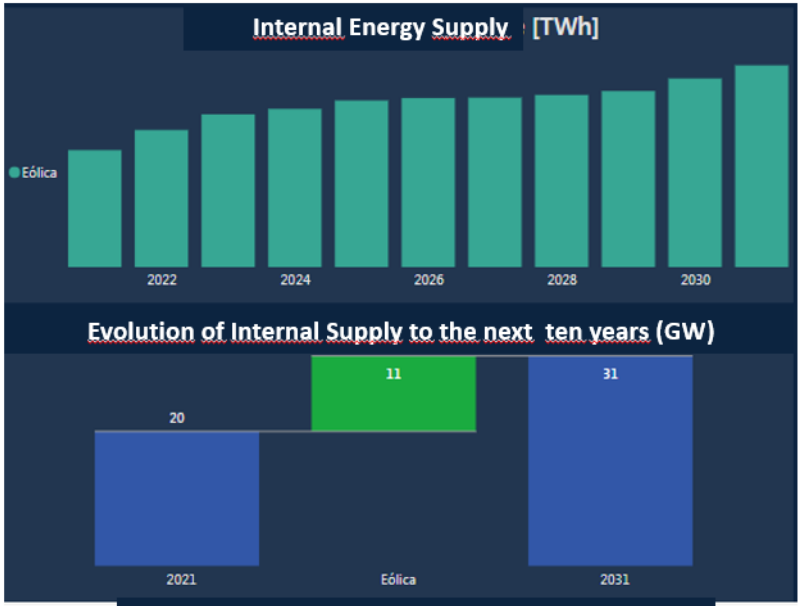
Source: FARIAS, 2007.

PDE 2031|Internal Energy Supply

Solar

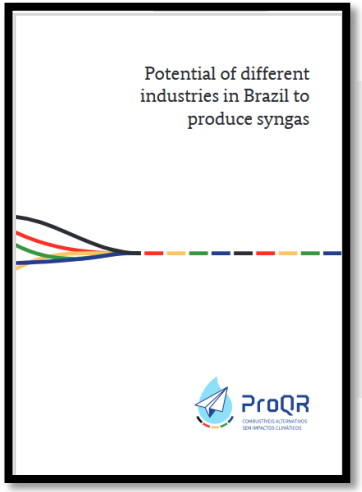


Wind



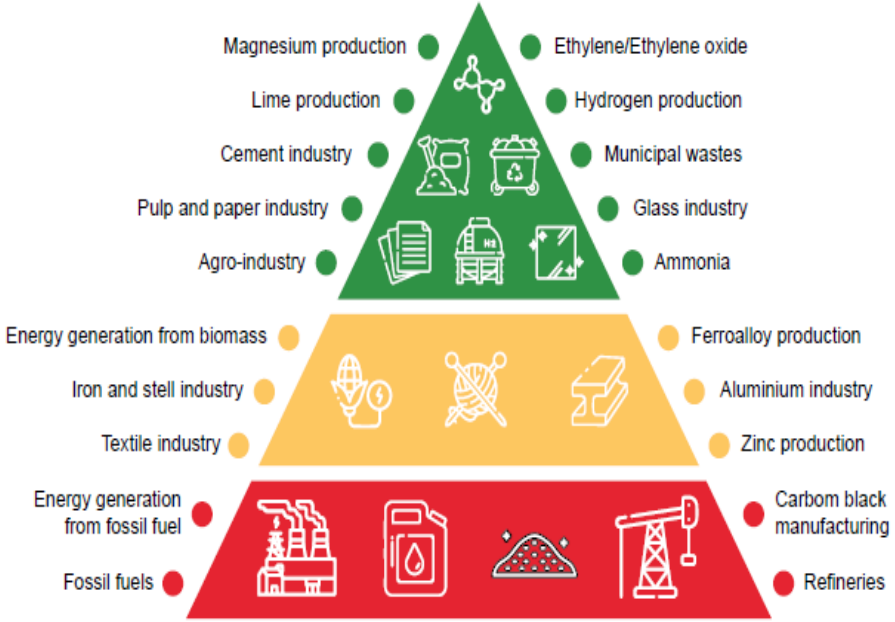
Source: EPE (2022). Available in: https://www.epe.gov.br/pt/publicacoes-dados-abertos/publicacoes/plano-decenal-de-expansao-de-energia-2031

Waste Potential of Industries



To analyze the potential of Brazilian's industries to produce syngas from its low value waste and by-products

Source: https://ptx-hub.org/wp-content/uploads/2021/09/Potential-Syngas-Production-Brazilian-Industry-ENG.pdf



Brazilian Industries Resource

Wastes and its potential for energy production

Technology Collaboration Programme on Advanced Motor Fuels

SOY	RICE	SUGAR CANE	CORN	STEEL	CELLULOSE INDUSTRIES	CEMENT
						
Straw, Glycerine Country (t) 299,108,536 238,979 Regional (t) 80,235,174 (MT) 63,490 (RS) Factor/ton harvested 1,52	Straw, husk Country (t) 20,810,901 Regional (t) 14,898,045 (RS) Factor/ton harvested 1,24	Straw (leaves and tips) bagasse, CO_2 Country (t) 146,296,782 Regional (t) 77,781,228 (SP) Factor/ton harvested 0,14	Stem, straw, bark, cobs Country (t) 158,660,843 Regional (t) 51,038,319 (MT) Factor/ton harvested 1,25	CO_2, sludge Country (t) 31,944,563 Regional (t) 9,558,017 (MG) 1.56 t CO_2 per ton of crude steel	CO_2, sludge, black liquor Country (t) 25,236,865 Regional (t) 5,745,931 (BA)	CO_2 Country (t) 22,267,418 Regional (t) 5,297,780 (MG) 0.55t CO_2 / ton of prod. cement

Source: https://ptx-hub.org/wp-content/uploads/2021/09/Potential-Syngas-Production-Brazilian-Industry-ENG.pdf

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Production Forecasts

RICE

Variação % 2020/21 a 2030/31	
Produção (mil t)	3,5%
Consumo (mil t)	-2,2%
Importação (mil t)	-18,8%

SOY

Variação % 2020/21 a 2030/31	
Produção (mil t)	29,5%
Consumo (mil t)	19,6%
Exportação (mil t)	33,6%

CORN

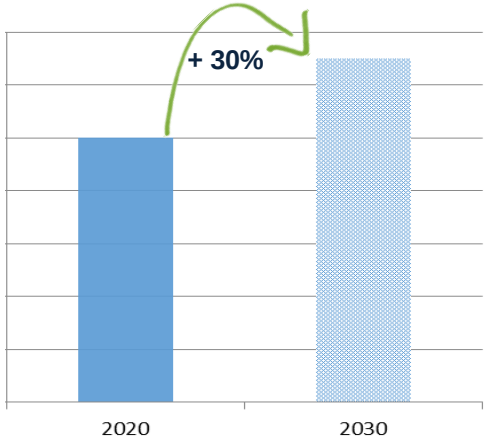
Variação % 2020/21 a 2030/31	
Produção (mil t)	28,7%
Consumo (mil t)	23,1%
Exportação (mil t)	43,8%

CELLULOSE

Variação % 2020/21 a 2030/31	
Produção (mil t)	27,6%
Consumo (mil t)	9,6%
Exportação (mil t)	34,7%

Source: https://www.gov.br/agricultura/pt-br/assuntos/politica-agricola/todas-publicacoes-de-politica-agricola/projecoes-do-agronegocio/projecoes-do-agronegocio-2020-2021-a-2030-2031.pdf/view

Average Production Growth



Energy Potential Production Forecast

What is the future we foresee (and how to get there)

- Energy systems will follow a process of carbon intensity reduction, in an energy transition branded by strong competition (among different technological alternatives).
- The climate agenda will increasingly influence international trade and international relations.
- The global energy mix will the most diverse the world has ever seen by 2050.
- There is a global technological race, with several routes and alternatives capable of assuming a relevant role in the energy transition, and we will probably face emerging industries coexisting and eventually replacing the traditional technologies.
- Considering the importance of flexible paths for the energy transition (avoiding technological locks), Brazil, given all its potential, has great opportunities in hydrogen economy.
- Countries such as Brazil, which present great supply of renewable energy resources, will promote a greater international insertion and participation in the global decisions regarding energy.

THANK YOU!!!

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