Green Hydrogen

A new
way for
**Rio Grande
do Sul.**

2023

GOVERNO
DO ESTADO
RIO
GRANDE
DO SUL
O futuro nos une.

Why Rio Grande do Sul (Brazil)?

GH2 production depends on the competitiveness of renewable energy, commitment to the agenda and local differentials in demand and infrastructure.

Competitive diferentials

DEMAND

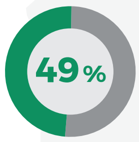
The economy of Rio Grande do Sul is highly representative in sectors that can benefit from Green Hydrogen.

LOGISTICS

Transmission lines, public ports, licensing spaces for outflow, cabotage and long-haul waterway transport system.

VIABILITY

The only production matrix in Brazil that contains a production and commercialization feasibility study (McKinsey).



RS energy consumption sources impacted by green hydrogen applications.

- Chemical Industry
- Agriculture
- Refineries - coke
- Petroleum products and Biofuels

10 favorable locations for the development of the GH2 chain

Competitiveness of the Renewable Energy

WIND

- Significant increase in the state's energy matrix (2% in 2010 and 19% in 2020)
- 10 GW licensed and total capacity of 103 GW on-shore and 108 GW off-shore.

PHOTOVOLTAIC

- Theoretical total solar installable capacity of approximately 100 GW on-shore with approximately 1% already in operation or planned

Political commitment

DECARBONIZATION AGENDA

- ✓ COP26 and 27
- ✓ Race to zero
- ✓ Race to resilience
- ✓ Under2 Coalition

COMPANIES

- ✓ White Martins
- ✓ Enerfin
- ✓ Neoenergia

CONTACT WITH INVESTMENT FUNDS

Main sources of H2

		Low Carbon H2		
	GRAY H_2	BLUE H_2	TURQUOISE H_2	GREEN H_2
Feedstock	Natural gas	Natural gas	Biomass or biofuels	Water
Production Process	Split natural gas[1] into H_2 e CO_2	Similar to Gray, but with CO_2 sequestration and/or storage	Catalytic reforming[2], gasification3 or anaerobic digestion4 with or without CCUS (Carbon Capture, Use and Storage)	Splitting water into H_2 and O_2 in an electrolyser powered by renewable energy
CO_2 emissions CO_2 Kg/H_2 Kg produced	~10	~1-3 (most CO_2 stored)	n.a.	~0 (Assuming a mix of green electricity, typically solar and wind)

Focus of discussion

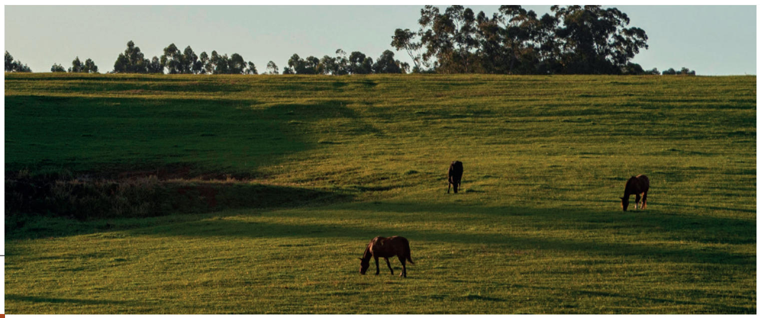
1. Process: Sulfur Removal, Syngas Production via Steam Methane Reforming (SMR) or Automatic Thermal Reforming (ATR), CO Shift Reaction, Purification. The latter is expected to offer greater efficiency in combination with CCS. Furthermore, gray hydrogen can also be produced from coal gasification;
2. Also called hydrogen reforming or catalytic oxidation, it is a method of producing hydrogen from hydrocarbons;
3. Processes that transform solid or liquid fuels into a fuel mixture of gases generating CO and H_2;
4. **Degradation of organic compounds without simpler substances (eg: CH4 and CO_2), using anaerobic microorganisms;**

Source: EPE

What is GH_2

Green Hydrogen (GH_2) consists of hydrogen generated by renewable energy, being an energy source of wide applicability with significantly lower carbon emissions than gray H_2 or other fossil fuels.

Opportunities for the southern region



DECARBONIZATION AS A GOAL

IMPROVEMENT OF THE USE OF NATURAL RESOURCES

DECREASE OF THE ENVIRONMENTAL IMPACTS ON ENERGY GENERATION AND USE

GENERATION OF JOBS , INCOME AND IMPROVEMENT IN THE QUALITY OF LIFE

INCREASE IN ENERGY SECURITY

REGIONAL INTEGRATED DEVELOPMENT

What RS offers

NATURAL RESOURCES

- Natural resources in abundance (energy generation – carbon free)
- Sea coast and lagoons
- 82% of the electric energy matrix is renewable

INFRASTRUCTURE

- Logistic and production base
- Transmission lines
- Port structure
- Waterways
- Roadways
- Railways
- Universities and science and technology centers

MARKET

- Internal consumption
- External market
- Added value in the local productive sector
- Tax incentive (Fundopem/RS)

Most relevant GH_2 applications for RS

INDUSTRY FEEDSTOCK

Conventional Routes

Refineries

Refap's Hydrogen Generating Unit has the capacity to produce 60 KTA of Gray H_2. Petroleum derivatives represent 5% of VTI.

Low carbon routes

Ammonia for fertilizers

Nitrogen fertilizer imports totaled 620 kT in 2021 (exc. Urea). The value of imports corresponds to 0.8% of VTI.

Methanol

Methanol imports from RS amounted to 20 KT in 2021. Methanol is used in the biodiesel industry, representing 0.6% of VTI.

Steel

Although the steel industry accounts for 1% of the VTI, the non-integrated route in RS reduces the possibilities of H_2 application.

ENERGY CARRIER

Transport

H_2 for passenger cars

RS has 8% of the car fleet. Road energy consumption represents 45% of the state's total consumption.

Long distance rail freight

Rails could be decarbonised using hydrogen or electricity as a diesel substitute.

Air transport

Air energy consumption representsless than 1% of consumption in the air transport. RS does not have a national/international air hub.

Road transport

Focus on trucks (85% of the heavy duty fleet). RS has 8% of the truck fleet. Road energy consumption represents 45% of the State's total consumption.

Sea transport

Porto de Rio Grande is the 5th busiest port in Brazil.

Heat for industry and services

Medium and high degree heating

Natural gas, mineral coal and diesel for energy purposes add up to 800,000 TOE in the industry, representing 6% of state consumption.

Combined cycleturbine

Mineral coal and natural gas consumption add up to 1.7 MTOE in the energy transformation process. Restriction of natural gas prevents the complete use of thermoelectric plants.

Mix of H_2 gas

Hydrogen can be added to the natural gas network, increasing the overall supply and enabling a better supply-demand balance.

BBenefits of GH_2 in RS

Scenario	Adoption of low complexity applications	Adoption of low and medium complexity applications	Adoption of low, medium and high complexity applications
Applications adopted in the scenario	Use in refineries, rail transport and cycleturbines	» Use in refineries, road transport and cycleturbines » Use in fertilizers, methanol, industrial heating, sea transport, gas mixtures	» Use in refineries, road transport and cycleturbines » Use in fertilizers, methanol, industrial heating, sea transport, gas mixtures » Use in road transport and passenger cars
Cumulative estimates up to 2040 PIB	~R$ 3,7 bi (1% of the RS annual GDP of 2021)	~R$ 33,6 bi (6% of the RS annual GDP of 2021)	~R$ 62 bi (11% of the RS annual GDP of 2021)
Jobs	~2 mil	~25 mil	~41 mil

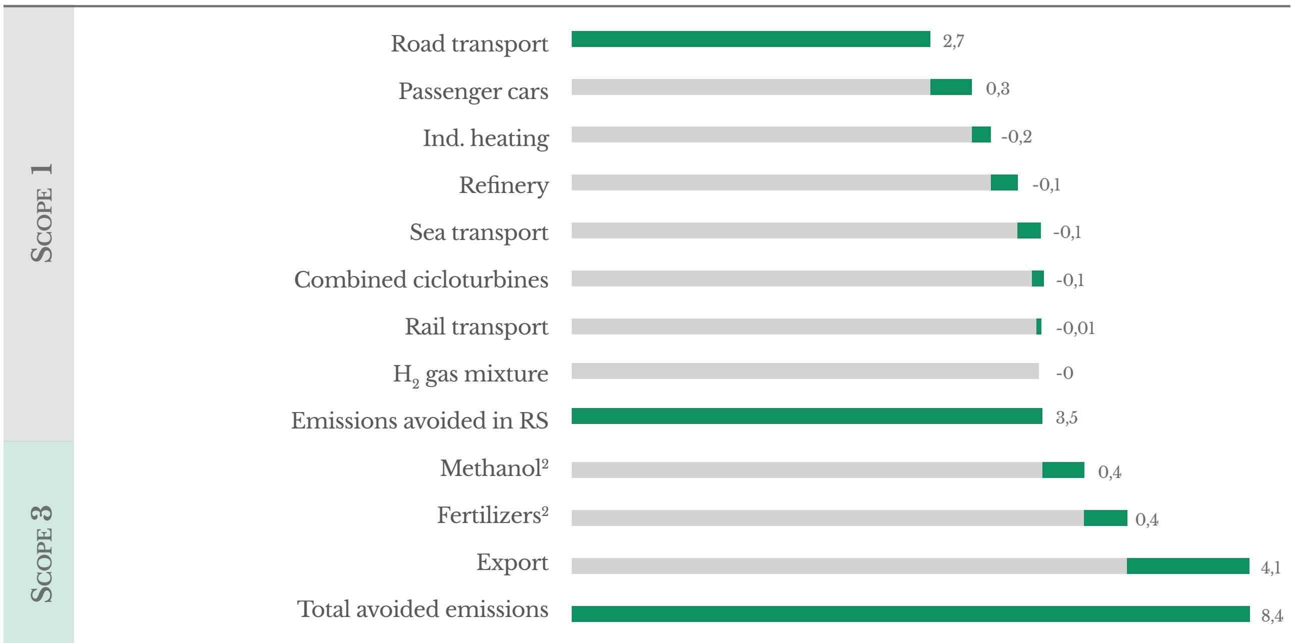
Note: Amounts at 2022 prices in reais without discount rate, considering average exchange rate for 2022 according to IPEA of USD/BRL of 5.1. Given the existence of factors linked to the dollar, exchange rate volatility can affect the size of long-term values

Source: FIPE/DEE, OECD input/output tables, IBGE/SIDRA, CAGED

How can GH_2 help to reduce carbon emissions in RS by 2040

Reduction of emissions in RS by application[1] – scenario[3]

2040, $MtCO_2e$/year



~3,5 a 8,4

$MtCO_2e$/year

in reducing emissions scope 1[1] and 3[1], by 2040

~4%[2] a 9%[3]

of total current scope 1[1] emissions from the state of RS[3]

~17%[4] a 38%[5]

of current Scope 1[1] emissions from sectors in RS where GH_2 is applicable[6]

1. Scope 1: emissions released as a direct result of operations within the state; Scope 3: indirect emissions that occur in the state's value chain;
2. Potential emission reduction of 3.5 $MtCO_2e$ in 2040 vs. total emissions of 84.3 $MtCO_2e$ RS in 2020 (according to the Climate Observatory using the GWP-AR5 methodology);
3. Considering RS contribution to total emission reductions (8.4 MtCO2e in scope 1 and 3) vs. the state's total emissions (84.3 $MtCO_2$ in scope 1);
4. Emission reduction potential of 3.5 and 8.4 $MtCO_2e$ in 2040 vs. emissions of 20.2 $MtCO_2e$ in sectors of RS where GH2 is applicable;
5. Considering RS contribution to total emission reductions (8.4 $MtCO_2e$ in scope 1 and 3) vs. emissions where GH2 is applicable in the state (20.2 $MtCO_2$);
6. Applicable sectors include synthetic fertilizers in agriculture, burning fuel in road, air, rail and water transport, fuel production in refineries, industrial heating, use of fuel in agriculture, fuel consumption for industrial processes of cement, pig iron and steel

Source: Climate Observatory

Final considerations

RS has great wind and solar potential for the development of GH_2 projects

Current economy, infrastructure and strategic position for GH_2 projects

Current and projected internal and external demands are adequate for scaled-up developments

GH_2 plays a central role in helping the world achieve carbon neutrality by 2050 and limiting global warming to 1.5°C

GH_2 is key to enabling a decarbonized energy system

Competitive GH_2 production costs in the national and international scenario

More information about GH_2
in Rio Grande do Sul:

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