INTERNATIONAL PARTNERSHIP FOR HYDROGEN AND FUEL CELLS IN THE ECONOMY

IPHE Country Update December 2020: Brazil

Name	Dante Hollanda
Contact Information	+ 55 61 98280-5111 dante.hollanda@mctic.gov.br
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1. New Initiatives, Programs, and Policies on Hydrogen and Fuel Cells

Since June 2020, the Ministry of Science, Technology and Innovation (MCTI) has been discussing internally its Hydrogen Energy Actions for 2021. To help the Ministry, a form was disseminated among numerous Brazilian partners seeking views to guide the Ministry's actions for the next few years. After collecting contributions from 20 institutions, the Ministry expects to have a governmental action plan in the first semester of 2021.

Also in June 2020, the Brazilian-German Industry and Commerce Association (AHK) started to prepare for the "Sector Mapping of Green Hydrogen in Brazil" project under the German-Brazilian Energy Partnership. The objective of this study is to identify the main stakeholders involved today in the value chain of hydrogen in Brazil. In addition, the study will give a general vision on the main technologies for green hydrogen production and Power-to-X, and its status in Brazil.

The study intends to give an overview of what is the current consumption of hydrogen in Brazil and who are its main consumers, as well as what is the production and who are the main producers and locations of production of green hydrogen. It will also investigate what are the main hydrogen and PtX generation technologies used in Brazil and what is the development forecast in the current scenario in the Brazilian matrix. The results will provide a list of the main stakeholders in Brazil along the green hydrogen value chain and the PtX tracking product, and will try to identify the interests of Brazilian industry in the introduction of green hydrogen in the Brazilian energy matrix.

The preliminary results were presented at the BW Expo Summit Digital 2020 November (17^{th}-19^{th} 2020). The complete study will be delivered on November 30th to the German International Cooperation Agency (GIZ) and the Ministry of Mines and Energy (MME) and will serve as a basis for the Ministry to initiate a revision of the National Roadmap for the Hydrogen Economy in Brazil.

The Brazilian Hydrogen Association (ABH2) believes that the time has come to join forces for the large-scale use of hydrogen as an energy carrier in Brazil. Throughout 2020, ABH2 has partnered with MCTI to work together, holding meetings with various companies and government agencies in order to understand the national scenario and develop a strategy for hydrogen energy in Brazil. Among them, the Energy Research Office (EPE), which develops energy planning for MME; Electric Center Research Group (GESEL), a research center focused on electricity and economy; the National Electricity Agency (ANEEL), the regulatory agency for the electricity sector in Brazil, professional associations, among others.

2. Hydrogen and Fuel Cell R&D Update

In the International Chem-E-Car Competition of the American Institute of Chemical Engineering (AIChE), the Centro Universitário FEI (FEI University Center), representing

Brazil, received the first Design and Safety award, using an open-cathode fuel cell vehicle integrated into the chassis.

3. Demonstration, Deployments, and Workforce Developments Update

In March 2020, Itaipu Binacional initiated investments in a new agreement with the Technological Park Itaipu Foundation, with the main objective of promoting research and business generation on the theme of hydrogen, contributing significantly to the basis for creating the Green Hydrogen Economy. With regard to research activities, it is important to highlight that the main focus is on the development of methods of operation and maintenance of the Hydrogen Production Plant by alkaline water electrolysis and generation of electrical energy using PEM fuel cell. For example, a systematic study is being carried out on the alkaline electrolyser with a production capacity of 10 Nm3 of hydrogen per hour on a 6 kW PEM fuel cell, in order to understand the degradation and corrosion processes, in addition to search spare parts supplied by national companies.

Also, many safety procedures have been developed by the project team based on their practical and theoretical experience. In addition, studies are being carried out to develop NiFe-based electrodes using national raw material, as well as electrode-position processes to produce the electrodes. Studies on chemically modified chitosan-based membranes, obtained from freshwater shrimp shells, have been carried out with the aim of using national inputs in PEM fuel cells. Finally, combustion studies of mixtures of biomethane and hydrogen have been conducted. This issues is of specific interest due to the large capacity for biomethane production from biogas in the western region of Paraná State thus making it an energy input with high potential for use in this region.

4. Events and Solicitations

4.1 ABH2 proposes to co-host with IPHE and the IADB (Inter-American Development Bank), a virtual event in February 2021, when a new study under development on hydrogen in the Latin America and the Caribbean will be published.

4.2 The BW Expo Summit Digital 2020 took place virtually 17 - 19 November with more than 3,000 participants. The program related to hydrogen was the following: https://www.bwexpo.com.br/

- **Day 17.11 at the Palco BW:**Opening Paulo Alvarenga, CEO ThyssenKrupp
- Introduction Monica Saraiva Panik
- Presentation Prof. Paulo Emílio de Miranda “Hydrogen Scenario in Brazil”
- Presentation Ansgar Pinkowski from the Chamber of Commerce and Industry and Green Alliance Brazil Germany “Results of the Hydrogen Sectormapping Brasil study ordered by the Ministry of Mines and Energy and GIZ

Day 17.11 at the Universo BW “Sala Transformação Energética – Hidrogênio”:

- Presentations “International Hydrogen Scenario”, from leading countries including Germany, the United States and Japan. In addition to the presentations, discussion with each speaker: Loana Lima from the Chamber of Commerce and Industry and from the Green Alliance Brazil Germany, Sunita Satyapal US Department of Energy, and Katsuhiko Hirose, CEO HyWealth

- SAE Brasil & Ballard Student H2 Challenge Opening Panel with a statement from Prof. Evaldo Ferreira Vilela, President of CNPq, and testimonials from MCTI, SAE Brasil, ANFAVEA and Ballard
- Workshop “Green Hydrogen: A New Business for the Electric Sector, with specialists from ThyssenKrupp, Base and Gesel and a debate with companies in the sector.
- Virtual exhibition "Sustainability Transforming the Cities of the Future" by Ronaldo Lopes, the creator of the Challenge vehicles and the character BW.

Day 18.11 at the Universo BW “Sala Transformação Energética – Hidrogênio”:

- Technical Group and Teams SHOW of SAE Brasil & Ballard Student H2 Challenge
- Workshop: The Potential of Biofuels for Hydrogen Production, with specialists from UNICAMP, Raízen and Hytron
- Workshop shared with BW curator Yuri Tisi, on Plastic and Biomass Waste for Hydrogen Production and with the specialist from Recupera
- Presentation MEC (Ministry of Education)’s ENERGIF Program, which supports R&D in wind and solar energy, energy efficiency in industry and buildings, biogas, biomethane, biofuels, renewable hydrogen and electric mobility.

Day 19.11 at the Palco BW:

- Presentation "Brazilian Hydrogen Bus" at EMTU / SP – Monica Saraiva Panik
- Presentation "How can Energy Transformation bring new business to Brazil?" with project ideas for Brazil in different Brazilian regions – Monica Saraiva Panik

Day 19.11 in the “Energy Transformation - Hydrogen” Room:

- Award Ceremony and Certificates to the Teams of SAE Brasil & Ballard Student H2 Challenge, and the SAE Brasil & Siemens Automotive Virtual Challenge, with the special participation of the IPHE Education & Outreach (E&O) Working Group Early Career Chapter. In this panel there was the pairing and linking of the program in partnership with ANFAVEA, called “Adopt a University”, which is promoting the exchange between industry experts and students from the Challenge teams.
- “Hydrogen Latin America” workshop with government representatives and hydrogen associations from Brazil, Chile, Argentina, Mexico and Colombia, showing the potential of these countries to become potential global suppliers of green hydrogen.
- Full presentation “How can Energy Transformation bring new business to Brazil?” – Monica Saraiva Panik

Results of Workshops at the BW Expo Summit Digital 2020

Workshop “Green Hydrogen: A New Business for the Utility Sector”

During the workshop it was shown that green hydrogen represents a great potential for new business for the Electricity Sector in Brazil. The Technologies of Power-to-hydrogen, Power-to-Methane, Power-to-Biogas, Power-to-Syngas, allow the companies that generate electricity, to start producing and commercializing fuels (H2) and industrial gases.

ThyssenKrupp, presented its new business unit in Brazil for large electrolyzers and pointed out that Brazil is able to install a green hydrogen plant in any region due to the interconnection of the electrical system and its 83% renewable energy matrix.

The company Base Energia Sustentável presented the pioneering projects in Brazil at CESP and Furnas, which are demonstrating the production and storage of green hydrogen in a combined system between hydroelectric and solar sources. The project implemented at CESP (Companhia Energética de São Paulo) promoted the manufacture the first Brazilian PEM electrolyzer and a hydrogen tank.

The focus of the Furnas project is focused on scaling up. Simulations have been made to envision the possibility of energy storage and synergy with primary sources (solar and hydroelectric) to optimize results. In addition, hydrogen is produced and stored during the rainy season for months and reconverted to the system when necessary.

GESEL - Study Group for the Electric Sector said that Brazil will have an important role in this global market because it is one of the countries that can produce green hydrogen competitively. The goal of the European Union establishes its electric matrix in 85% of renewable sources for 2050, and Brazil in 2020, already has that. This means that we are 30 years ahead in this achievement. Green hydrogen will be a global commodity, reducing the dependence of European countries on some centers that export oil and natural gas. With a more global production, the hydrogen market will foster more economical and competitive trade relations, with less geopolitical interference. In addition to the fact that Brazil is a continental and tropical country, which guarantees the potential of renewable energy unmatched in the world, the regulatory model for the expansion of installed capacity is a success. Since 2000, installed capacity and transmission lines have been expanded through competitive auctions. The contracting models can be directed to hydrogen production on national soil and exported to the world. For that, it is enough to set up production plants on the Brazilian coast or in the Northeast region, for example. It is a development analogous to what happened with coffee.

Workshop "The Potential of Biofuels for the Production of Hydrogen"

The production of green hydrogen using biofuels can contribute and accelerate the decarbonization of the transport sector, which is among the areas that emit the most greenhouse gases in the world.
The mentor of research and development and innovation SAE Brasil, stated that clean solutions and technologies will need to enter the market more actively and quickly. He recalled that the entry of the Flex system (using ethanol and gasoline in an internal combustion engine) technology was well accepted in the market, remaining strong, even in times of crisis, because the power of choice is in the hands of users. “But, what will the future of mobility be like, since we will have to tie a new structure, expanding the idea of flex? In addition to ethanol, Brazil has the potential of the biomass market. But, for that, it is necessary to define a strategic plan for the future energy and mobility market, in order, for example, to plan biomass production in an appropriate way.

The consultant for New Technologies and Industrial Processes at Raízen, presented some data on the company's biomass production potential. Currently, the potential of available biomass is 34.4 tons per hectare or 0.43 tons per ton of cane, with 0.28t coming from bagasse and 0.15t from straw.

The director of Hytron showed that the production of green hydrogen from ethanol is quite advantageous, since their equipment consumes 7.61 liters of ethanol for the production of 1 kg of hydrogen, consuming 18 liters of water and ten times less energy than the water electrolysis process. “Mobility in all its forms - light, heavy, maritime, rail vehicles, among others - tends to be electric because there is more efficiency and less pollution. As a

result, complementary technologies will be necessary to provide its operation, as is the case with hydrogen. In a hypothetical situation, he performed simulations to demonstrate the feasibility of producing green hydrogen from ethanol. An SUV model would need 7.5 green hydrogen to achieve a range of 1,125 km. In other words, ethanol consumption would be in the order of 57 liters of ethanol to supply the 7.5 kg and the average consumption would reach 20 km / l. The refueling would take approximately 3 minutes. In his calculations, the cost of kg of hydrogen produced from ethanol varies between US$2.5 and US$5, an extremely competitive value worldwide, because today this production varies between US$7 and US$9.

Workshop “Production of H2 from Plastic Waste and Biomass”

The workshop was attended by the president of ABREN (Brazilian Association for Energy Recovery of Waste) and the specialist Flávio Ortigão from Recupera, who has gasification technology that produces high-purity hydrogen from plastic waste.

Hydrogen can be produced by the gasification of renewable, residual inputs, or the product of sustainable management of forest and plastic biomes at the end of life, via synthesis gas and without emissions, through the simple separation of syngas. By converting plastics, which are mostly derived from fossil oil and composed mainly of hydrogen and carbon, into emission-free synthetic gas, we avoid the same amount of virgin fossil oil and produce H2 avoiding CO2 emissions. White hydrogen is a viable way to turn the problem of non-recyclable plastics into a green solution.

Workshop “Hydrogen Latin America”

The workshop brought together representatives from governments and industry associations from Brazil, Argentina, Chile, Mexico and Colombia, as well as representatives from technology industries to discuss the potential of Latin American countries for the production and export of green hydrogen.

The president of the Chilean Hydrogen Association, presented the activities in the hydrogen sector in Chile, focused on the generation of green hydrogen from solar energy and its use for the decarbonization of the mining and public transport sector. Chile is currently leading the Latin American region in terms of strategic plans and government initiatives for this hydrogen sector.

The project manager of the Energy Storage Technology R&D group at the National Institute of Electricity and Clean Energy - Mexico (INEEL), presented the initiatives in Mexico, focused on the areas of hydrogen storage. Micro-grids and research in electrolysis and fuel cell technologies.

The president of the Brazilian Hydrogen Association presented the activities in Brazil. The president of the Argentine Hydrogen Association presented the project Green Hydrogen Production in Patagonia using wind energy, among other activities.

The Hinicio's consultant presented the activities of the hydrogen sector in Colombia, which includes the partnership among the Federal Governments of Chile and Colombia, which signed a cooperation to leverage the hydrogen sector in their countries.

The new business development manager at Siemens Energy introduced the company's large-scale electrolyzer technology.

Several representatives of government agencies from Brazil, Chile, Mexico, Argentina and Colombia participated as well in this workshop. Latin American countries have numerous natural resources and sources of renewable energy, large industrial parks, in addition to representing large consumer markets, and therefore can contribute to the decarbonization of the global economy and should be included in the global map of international cooperation.

Hydrogen opens doors to Latin American countries for new business opportunities in the domestic market, international trade, job creation and for “Green Recovery” in several sectors such as transport, mining, steel, and the chemical industry.

SAE Brasil Student H2 Challenge

The SAE Brasil & Ballard Student H2 Challenge had a 3 days program at the BW Expo Summit Digital 2020 with participants from the SAE organization and technical groups, the student teams and representatives of the following supporting institutions:

- CNPq (made the import process of the fuel cell stacks donated by Ballard)
- Ministry of Science, Technology and Innovation (MCTI)
- ANFAVEA (Brazilian Association of the Automotive Manufacturers – supported the program “Adopt a University”, which is promoting the exchange between industry experts and students from the Challenge teams
- Ballard Power Systems (donated 10 fuel cell stacks)
- Air Products (donated the H2 cylinders)
- WEG Equipamentos Elétricos (donated an inverter for a validation text bench of the electric drive train system and adopted one university)
- SEG Automotive (donated 8 electric motors)
- Siemens Automotive (donated 8 software licenses for vehicle simulations)

The Awards and Certificates Ceremony and Virtual Challenge had the special participation of the IPHE Education & Outreach (E&O) Working Group Early Career Chapter, who gave certificates for the 3 first winner teams of the digital phases, and gave them the opportunity to present their vehicles and teams at the next meeting.

The pairing and linking of the “Adopt a University” program, which is promoting the exchange between industry experts and students from the Challenge teams, was made and formed the following pairs “Companies/Universities”:

AVL	UNICAMP
FORD	SENAI CIMATEC
General Motors	UFABC
Mercedes	UFRJ
Mercedes	MAUA
SEMCON	UNIFEI
Volkswagen	FEI
WEG	FACENS

The companies will support the teams on engineering, logistics and infrastructure during the vehicle construction phase and during the track competition to be scheduled according to the COVID-19 scenario.

The SAE Brasil & Ballard Student H2 Challenge had 15 Brazilian universities registered, 170 students trained per week over 3 weeks, on hydrogen and fuel cell technologies and 8 universities were selected during the digital phases to develop, construct, and operate in a test track 4 Bajas and 4 Formula SAE fuel cell hybrids. This is the first competition worldwide in this category.

5. Investments: Government and Collaborative Hydrogen and Fuel Cell Funding

Nothing to report for this period.

6. Regulations, Codes & Standards, and Safety Update

Nothing to report for this period.

Summary Country Update December 2020: Brazil

Transportation	Target Number	Current Status	Partnerships, Strategic Approach	Support Mechanism
Fuel Cell Vehicles[1]				
FC Bus		1 operational hybrid HFC bus		
Fuel Cell Trucks[2]				
Forklifts				
H_2 Refueling Stations	**Target Number**	**Current Status**	**Partnerships, Strategic Approach**	**Support Mechanism**
70 MPa On-Site Production				
70 MPa Delivered				
35 MPa On-Site Production		1 hydrogen production and refuelling station.		
35 MPa Delivered				

[1] Includes Fuel Cell Electric Vehicles with Range Extenders

[2] As above

Stationary	Target Number[3]	Current Status	Partnerships, Strategic Approach	Support Mechanism
Small[4]				
Medium[5]				
Large[6]				
District Grid[7]				
Regional Grid[8]				
Telecom backup				
H_2 Production	**Target[9]**	**Current Status**	**Partnerships, Strategic Approach**	**Support Mechanism**
Fossil Fuels[10]				
Water Electrolysis[11] (PEM, Alkaline, SOEC)		1 hydrogen production (water electrolysis) and refuelling station		

[3] Targets can be units installed and/or total installed capacity in the size range indicated
[4] <5 kW (e.g., Residential Use)
[5] 5kW – 400 kW (e.g., Distributed Residential Use)
[6] 0.3MW – 10 MW (e.g., Industrial Use)
[7] 1MW – 30 MW (e.g., Grid Stability, Ancillary Services)
[8] 30MW plus (e.g., Grid Storage and Systems Management)
[9] Target can be by quantity (Nm^3, kg, t) and by percentage of total production; also, reference to efficiency capabilities can be a target
[10] Hydrogen produced by reforming processes
[11] Please indicate if targets relate to a specific technology (PEM, Alkaline, SOEC)

By-product H_2				
Energy Storage from Renewables	**Target[12]**	**Current Status**	**Partnership, Strategic Approach**	**Support Mechanism**
Installed Electrolyser Capacity				
Power to Power[13] Capacity	1. Pilot Hydrogen-based energy storage plant built to store 200 MWh/year. 2. Pilot Hydrogen-based energy storage plant built to store 730 MWh/year.	1. Pilot plant built, ongoing campaign of measures. 2. Pilot plant under construction.	1. ANEEL, CESP, BASE Sustainable Energy (BASE), USP, UNICAMP, UNESP, PV Solar, MFAP Consultoria. 2. ANEEL, FURNAS, BASE Sustainable Energy, Brandenburg Technology University, Technology and Innovation Institute of Goiás (SENAI), UNICAMP, UNESP.	1. Brazilian R&D Fund. Total investment 8 million Euros. 2. Brazilian R&D Fund. Total investment 11.9 million Euros.

[12] Can be expressed in MW of Installed Capacity to use the electricity from renewable energy generation, and Annual MWh of stored energy capacity

[13] Operator has an obligation to return the electricity stored through the use of hydrogen back to electricity

Power to Gas[14] Capacity				

[14] Operator has the opportunity to provide the stored energy in the form of hydrogen back to the energy system through multiple channels (e.g., merchant product, enriched natural gas, synthetic methane for transportation, heating, electricity)