INTERNATIONAL PARTNERSHIP FOR
HYDROGEN AND FUEL CELLS IN THE ECONOMY

IPHE Country Update April, 2017: Brazil

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1. New Policy Initiatives on Hydrogen and Fuel Cell

- Reduction of annual state tax “IPVA” due to electric vehicle ownership in seven Brazilian states (Rio Grande do Sul, Sergipe, Pernambuco, Rio Grande do Norte, Ceara, Piaui and Maranhao). Depending on the State of Brazil as well as the size and specific application of the vehicle, this tax varies between 0.5% and 4% of the acquisition price of it.

- São Paulo City Hall has established by regulations that each purchaser of an electric vehicle (BEV, FCEV or HEV) shall be reimbursed during the first 5 years of car ownership by the portion of the state tax "IPVA" that otherwise would be distributed back to the City Hall (40%). Moreover, all electric vehicles have been exempted from the weekday driving restriction inside the expanded downtown border. São Paulo is the largest Brazilian city with estimated 12 million inhabitants and 8 million vehicles in 2016.

- The National Bank for Social and Economic Development (BNDES) determined better financing conditions for the purchase of hybrid and electric buses, with lower interest rates and longer financing term. BNDES is one of the largest development banks in the world and the most important for the long-term financing and investment in the Brazilian economy.

2. Hydrogen and Fuel Cell R&D Update

- Itaipu Technological Park Foundation (FPTI) has been investigating the use of hydrogen as an energy carrier that can be produced by water electrolysis in periods when the power demand decreases. Nowadays, in this case the hydropower plant delivers water to the spillways, wasting energy. Research on hydrogen as an energy vector has increased at FPTI with the installation of a Hydrogen Production Plant in 2014. The Nucleus of Research on Hydrogen (NUPHI) has studied the life cycle of hydrogen, the feasibility of its production from hydropower and its use on fuel cells for electric vehicles and auxiliary energy systems. In 2016, the production system was disassembled to study the internal parts, mainly the water electrolyser and its control monitoring system. This has generated much knowledge about the components of the hydrogen production system, allowing the formation of qualified human resources. Since 2016, technical-scientific partnerships have been intensified with the Federal University of Paraná, Federal University of Latin American Integration and the Federal University of São Carlos. NUPHI's research has generated three scientific articles

published in national and international journals. With the acquired knowledge, new proposals of research and development projects about energy storage were submitted to the Brazilian power generation company Eletronorte and to other companies.

Hydrogen Production Plant – FPTI/Itaipu

- Petrobras has a long experience on hydrogen production by steam reforming. Presently, efforts are being made to further reduce the hydrogen production cost. New products are being developed in partnership with suppliers based on monitoring and simulation of catalysts performance. There are ongoing projects on processes and catalysts to produce hydrogen from ethanol and/or heavy oil as alternative raw materials to natural gas.

- The National Institute of Technology (INT) has been developing a project funded by FINEP to build two fuel processors using ethanol or natural gas for hydrogen production. The fuel processors will produce hydrogen to feed a 1 kW PEM fuel cell using catalysts developed by the Hydrogen Production Network Project, part of the ProH2 Program of the Ministry of Science, Technology, Innovations and Communications (MCTIC). The demonstration units will start operation by August, 2017.

- The creation of the National Institute of Science and Technology (INCT) on Hydrogen and Fuel Cell for generation of renewable energy was approved by the Brazilian Government. It is formed by 13 institutions spread all around the country, and its main objective is to promote integrated actions and cooperation in the fields of Science, Technology and Innovation to develop national technology in energy systems based on fuel cells, aiming at efficient and low environmental impact power generation. The integrated action should involve: (i) fundamental and technological research; (ii) demonstrative technological projects; (iii) development of materials and prototypes (pre-commercial stage); (iv) formation of human resources. The institute will focus on application of fuel cell systems for distributed power generation, in isolated systems, prioritizing PEM and SOFC fuel cells types.

- The Energy and Nuclear Research Institute (IPEN) obtained three patents in 2016, all related to the production of catalysts and electrocatalysts used respectively in the steam reforming process and in fuel cells.

- The recently created Research Center for Gas Innovation – RCGI is the result of a partnership between Shell and Fapesp. The center is based at the University of São Paulo (USP) and aims to support high-level scientific research for the development of the energy sector. Hydrogen related research has a prominent role in the center. As included in its institutional description, RCGI will offer "innovative solutions to the technological problems related to natural gas, biogas, hydrogen and carbon dioxide emissions as well as providing support for the improvement of energy policies in the State of São Paulo, in Brazil and worldwide. In particular, it intends to increase the competitiveness of the industry of São Paulo and inform society of the enormous economic potential in the use of natural gas, biogas and hydrogen as sources of energy in the years to come". The institution has set up an excellent structure to receive research and innovation funding in the hydrogen area. For more information: http://www.rcgi.poli.usp.br/.

- The Hydrogen Laboratory at COPPE/UFRJ finished in February, 2017 a four-year project co-financed by BNDES and the enterprises Oxiteno S.A. and Energiah Ltda. for the development of innovative solid oxide fuel cells. Specialty anodes allowed the direct utilization of carbonaceous fuels; in one case of ethanol for distributed generation of electricity and in the other case of methane for the electrochemical synthesis of C2 type hydrocarbons. The project has produced several patents, two of them already approved: US 9,281,525 B2 – US 9,431,663 B2.

- The National Regulatory Agency for Electrical Energy (ANEEL) launched a call for projects under the R&D Program of the electric companies, regulated by the agency, for the development of energy storage systems (Call 21/2016). More than 100 companies were interested, and 29 proposals were submitted. In March 28th, the agency approved 23 of these proposals, and at least 2 of them use hydrogen as the base technology for the energy storage system. The projects will last until May 2021.

3. Demonstration and Deployments Update

- On April 5th, the project "Electric Traction Buses" closed its activities in an event held in Rio de Janeiro, RJ. The project was developed under a partnership between Furnas Centrais Elétricas and the Post-graduation and Engineering Research Institute Alberto Luiz Coimbra (COPPE), from the Federal University of Rio de Janeiro (UFRJ), through its Hydrogen Laboratory. It developed three prototypes of plug-in type electric traction buses, one electric, one hybrid electric-ethanol, and a hybrid electric-hydrogen one. More information on the latter is available at "Brazilian hybrid electric-hydrogen fuel cell bus: Improved on-board energy management system", International Journal of Hydrogen Energy, (http://www.sciencedirect.com/science/article/pii/S0360319917300216). A hydrogen refuelling station is presently under construction at UFRJ. The partnership has another ongoing project for the development of two ships with hybrid electric propulsion similar to the technologies developed for the hybrid buses.

- The project “Hydrogen Fuel Cell Buses for Urban Transport in Brazil” was successfully concluded in 2016 with three HFC buses and one hydrogen production and refueling station. The state of the art design of these three buses was preceded by the development and test of a prototype bus, in 2010.The new buses are low-entry buses, with two doors in each side, capacity for 75 passengers,12.6 m length and 14.1 ton weigh. They are equipped with a 150 kW fuel cell and 105 kW ion-Li technology batteries. The station was designed to refuel four buses daily, producing 6.0 kg H_2 per hour. During the tests, including operation in real conditions with passengers, the three buses ran a total of 12,000 km and presented an average hydrogen consumption of 13.7 kg / 100 km. The Brazil FCB project was developed under the fuel cell bus commercialization support program established by the UNDP and GEF, respectively the executing agency and main financial agency, and co-financed by the Brazilian Government, through FINEP. It also received contributions from a strong consortium of private companies, consisting of AES Eletropaulo, Ballard Power Systems, EPRI, Hydrogenics, Marcopolo, Nucellsys, Petrobras Distribuidora and Tuttotrasporti. The project was directed by the Brazilian Ministry of Mines and Energy and implemented by São Paulo Urban Transportation Metropolitan Enterprise (EMTU/SP).

The three new HFC buses, each one painted with colors representing Brazilian birds

Hydrogen production and refueling station

4. Events and Solicitations

- On April 5th, an event occurring in Rio de Janeiro/RJ marked the foundation of the Brazilian Hydrogen Association (ABH). The new entity aims to bring together research institutions, companies and specialists interested in the research, technological development and innovation of themes related to the hydrogen industry. ABH will be part of the International Association for Hydrogen Energy (IAHE) and will support the organization of the 22nd World Hydrogen Energy Conference – WHEC 2018, which will be held in Rio de Janeiro/Brazil.

- WHEC 2018 will occur in Rio de Janeiro, hosted by the Post-graduation and Engineering Research Institute Alberto Luiz Coimbra (COPPE), at the Federal University of Rio de Janeiro (UFRJ) from June 17 – 22, 2018 (http://www.whec2018.com).

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

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Summary Country Update April, 2017: Brazil

Transportation	Target Number	Current Status	Partnerships, Strategic Approach	Policy Support
Fuel Cell Vehicles[1]				
FCBus		4 HFC buses (3 new and one prototype) and 1 hybrid HFC bus		
Fuel Cell Trucks[2]				
Forklifts				
H_2 Refueling Stations	**Target Number**	**Current Status**	**Partnerships, Strategic Approach**	**Policy Support**
70 MPaOn-Site Production				
70 MPa Delivered				
35 MPa On-Site Production		1 hydrogen production and refuelling station. Another refuelling		

[1] Includes Fuel Cell Electric Vehicles with Range Extenders

[2] As above

		station is under construction.		
35 MPa Delivered				
Stationary	**Target Number[3]**	**Current Status**	**Partnerships, Strategic Approach**	**Policy Support**
Small[4]				
Medium[5]				
Large[6]				
District Grid[7]				
Regional Grid[8]				
Telecom backup				
H_2 Production	**Target[9]**	**Current Status**	**Partnerships, Strategic Approach**	**Policy Support**
Fossil Fuels[10]		2 fuel processors under construction (one using ethanol		

[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 capabilitiescan be a target
[10]Hydrogen produced by reforming processes

		and another one using natural gas)		
Water Electrolysis[11] (PEM, Alkaline, SOEC)		1 hydrogen production (water electrolysis) and refueling station.		
By-productH_2				
Energy Storage from Renewables	**Target[12]**	**Current Status**	**Partnership, Strategic Approach**	**Policy Support**
Power to Power[13] Capacity				
Power to Gas[14] Capacity				

[11] Please indicate if targets relate to a specific technology (PEM, Alkiline, SOEC)
[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
[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)