Ministry of Mines and Energy



Brazil Today

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Secretary of Oil, Natural Gas and Renewable Fuels

Shanghai, China - September 2010

PRESENTATION OUTLINE

- 1. Brazilian Energy Policy
- 2. Brazilian Energy Mix Update
- 3. Brazilian Experience in Renewable Fuels
- 4. R&D Program for Hydrogen and Fuel Cells
- 5. Brazilian Hydrogen Fuel Cell Buses
- 6. Regulations, Codes and Standards

The Brazilian Energy Policy

- To increase biofuels' share in energy matrix
- To promote energy security as well lower foreign dependence
- To protect the environment and the consumer
- To stimulate free and healthy competition on energy sector

Brazilian Energy Matrix (2009)



2008

Source: MME - Boletim Mensal de Energia (dez/09). (*) Preliminary data.

Brazilian Vehicle Fuel Mix (2009)

📓 Fossil 🔰 Renewable





Brazilian Experience in Renewable Fuels - Ethanol

Flex Fuel Fleet Growth: The main driver for ethanol market expansion



- Allows any mixture of hydrous ethanol and gasoline C (E25 to E100)
- In 2009, vehicle sales registered a growth of 11% in comparison to 2008, and the historical record of 3 million vehicles was reached. Flex-fuel sales represented 88.2% in 2009.
- Since 2003, until June/2010, more than 11 million flex-fuel vehicles were commercialized and its share in total light vehicles fleet is estimated in 37%.

Flex-fuel sales: From zero to 80% in 3 years!



Brazilian Ethanol: Growing Expectation



Source: MME (10 Years Energy Plan - PDE 2008-2017)

R&D Program for Hydrogen and Fuel Cells

Brazilian Hydrogen and Fuel Cells R&D Program – ProH2, coordinated by Ministry of Science and Technology, is based on research networks, focused on the development of fuel cells and hydrogen science and technologies in Brazil.

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- The program is based on network projects in five areas:
 - i. Hydrogen production
 - ii. PEM fuel cells
 - iii. SOFC fuel cells
 - iv. Systems, integration and engineering
 - v. Utilization, applications and use
 - A lot of research groups from universities and research centers

R&D Program for Hydrogen and Fuel Cells

ProH2 - Studies and Analysis

Hydrogen Energy In Brazil 2010-2020, study conducted by the Center for Strategic Studies and Management in Science (CGEE):

 technological prospecting on the Hydrogen Economy, aiming to get an analysis of the current scenario, and technology and market trends up to 2020 in Brazil. Only published in Portuguese:

http://www.cgee.org.br/busca/ConsultaProdutoNcomTopo.php?f=1&idProduto=6771

Some outputs from ProH2 research networks

PATENTS

- Catalysts for ethanol reforming without carbon production
- Modifications in the interface of gas diffusion electrodes that increased power density by 85% in small cells - IPT and IPEN

RESULTS

- Scale up in MEA (membrane electrode assembly) manufacturing to 20cmx20cm (world standard), operating in 500W cell
- Contracted Evonik (Degussa) to scale up production and commercialization of catalysts for fuel cells
- Structure for studies of long-term reliability
- Acquisition of cells (1, 2 and 5KW) from Brazilian manufacturers for demonstration and studies of liability (with technology from ProH2 networks). Bidding took place in July/2009.
- Development of nano-structured ceramic suspension for SOFC anodes

STUDIES

- Alternative membranes to "Nafion" with composites for operation at intermediate temperatures (100-200 ° C)
- Catalysts for direct oxidation of ethanol (direct ethanol cell)
- Specific anode for oxidation of methane directly to other chemicals (partnership with Oxiteno).
 Cell operates as an electrochemical reactor
- Specific anode for oxidation of ethanol in SOFC
- Spray pyrolysis process for deposition of ceramic layers. (Industrial application)
- Manufacture of ceramic plates by gluing tape

• Support the participation of Brazil (ABNT) in international normative organizations for hydrogen: ISO / TC 197.

Created in Brazil the Special Study Commission for Hydrogen Technologies (ABNT / CEET 00:001.67).

• Evaluating participation in Hy-safe

R&D Program for Hydrogen and Fuel Cells

Published 512 articles about hydrogen (90% on the last 10 years)

80 research projects at universities, research institutes and private companies

7 hydrogen fuel cells companies (Hytron, Uniteh, NovoCell, Clamper, Energiah, Raetech, BrasilH2)

4 H2 generation companies (Hytron, Eletrólise, and two others being created)

Brazilian Hydrogen Fuel Cell Bus - São Paulo, SP

Sponsors:



MINISTÉRIO DE MINAS E ENERGIA







United Nation Development Programme





SECRETARIA DOS TRANSPORTES METROPOLITANOS



PROJECT PARTNERS



FINEP

UNDP

 United Nations Development Program the GEF's implementing agency – technical and administrativ e support for the project.

•Global Environment Facility **m**ultilateral financing mechanism; its resources for this project are administrated by UNDP.

GEF

MME Ministry of

Mines and Energy – **e**xecuting agency for this project. • Financing Agency of **Studies and Projects** – the national sponsor agency, which belogns to the Ministry of Science and Technology. Its resources have been given to the MME, which itself forward to the UNDP.



EMTU

Metropolitan **Compay** – the implementing agency and national coordinator of the project. International Consortium

 Manufacturer and suppliers.

PROJECT'S STRATEGIC OBJECTIVES

Develop a public transportation with zero emission of pollutants, contributing to the reduction of pollution levels and greenhouse gases (GHG) in the atmosphere.

Demonstrate the viability of hydrogen fuel cell buses and the infrastructure to produce and fuel hydrogen.

Develop a national specification for hydrogen fuel cell buses based on Brazilian chassis and coaches.

Acquire and disseminate technical culture (manufacturing, operation and maintenance).

CONCEPTS INCORPORATED TO THE BUS PROJECT

The bus is safe, efficient, zero emission of pollutants, low floor and very low noise level.

Hybrid fuel cell propulsion system.

Develop engineering, testing and sharing knowledge, to achieve better performance, stronger commitment and involvement of Brazilian industry.

Promote a system to integrate components of advanced levels of development with national companies (know-how acquisition).

PROJECT'S MAIN ASPECTS



Brazil is the greatest world manufacturer and consumer of buses

The São Paulo metropolitan region has the highest concentration of bus all over the world

PROJECT'S MAIN ASPECTS



BUS GENERAL FEATURES





- •**Type:** Padron 12,6 m
- •Low Floor
- •Capacity: 63 passengers
- •Power: 210 kW
- •Hydrogen volume: 45 kg
- •Autonomy: 300 km

CONCEPT OF HYDROGEN FUEL STATION

 The hydrogen production and fuel station will be operated by Petrobras, with technical support provided by Hydrogenics;

- ✓ Modular station with possibility of future expansion;
- Production of hydrogen by electrolysis.





São Paulo's Bus Current Situation

The Bus

The Functional Tests of the bus took place initially at the factory in Caxias do Sul / RS, and later in EMTU / SP in 2009.

Verification Tests 1 at São Paulo streets, yet without of passengers, ended in August, 2010.

The beginning of the next Test Protocol (Verification Tests II, with passengers) will occur by the end of this month.

Production and supply infrastructure

Equipment for production and supply of hydrogen are installed and currently being integrated.

Technical staff to perform the commissioning of the hydrogen production and fuel station, monitored by Petrobras, which will be trained to perform the operation.

It is expected that the station will be operational by November of 2010.



















Future Prospects

Due to the transfer of the technology, Brazil's Hydrogen Fuel Cell Bus Project allows no dependence on exclusive suppliers. The next series of 3 buses, scheduled for 2011,will incorporate improvements over the prototype tests, including higher loading capacity. The nationalization of various components for the bus the next phase I will be ensured by transferring technological knowledge for the Brazilian industry.

Project Partnership:

Laboratório COPPE ACCOMPLISHMENT: de Hidrogênio UFR] COPPE/UFRJ PEMM FINANCIAL SUPPORT: E FINEP **R**CNPq FAPERJ EL: PETROBRAS SPONSORS: FETRANSPOR Rio de RIO Eletrobras USIMINAS COPPECLIMA PARTNERS: Ш20 ROTAREX RUSSCAA *+ ENERGIAH hubz G Ontrollato EnergySat ELECTROCELL' GUARDIAN Technologies

Technical Features

✓ Brazilian designed and fabricated monoblock type low-floor bus chassis and body

- ✓ Hybrid propulsion bus (battery + fuel cell) with regenerative braking
- ✓ The hydrogen fuel cell system engineering design was made by Electrocell
- ✓ Launching happened on May 26th, 2010 in Rio de Janeiro.



Brazilian hybrid electric fuel cell urban bus – Rio de Janeiro, RJ



Performance testing route

University City

Federal University of Rio de Janeiro



Rio de Janeiro Hydrogen Production and Fuel Station

- ✓ The CSD Compress, Storage and Dispenser was purchased from Air Products
- ✓ The electrolyzer is from Hydrogenics
- ✓ Operation: Petrobras

The station is very similar to São Paulo's. However has two differences as follows:

1) The RJ's station has a lower generation capacity - 15 Nm/h (sufficient to supply only one bus)

2) The station was originally designed to RJ, other projects envisioned to be made using mixtures of hydrogen and natural gas. Thus, this station will supply vehicles on pure hydrogen or mixtures of hydrogen and natural gas, varying the composition of hydrogen in the mixture 00-50% (by volume). Most stations that work with mixtures in the world have a maximum value of mixing something around 25-30%

Regulation, Codes and Standards

- INMETRO, part of Ministry of Development, Industry and Foreign Trade, national institute for metrology, industrial quality and management systems; national laboratory (R&D&I); accreditation of labs and certification organisms; regulatory agency; enquiry point of WTO in Brazil.
- Mathematical modeling of error sources in measuring variables in Fuel
 Cell testing benches; measurement uncertainty and reliability;
 dissemination.
- UTILH2 Project: Data mining on infrastructure status and needs on M&Q for future funding demands of Ministry of Science and Technology.

Standards for Hydrogen and Fuel Cells in 2010

ABNT NBR/IEC/TS 62282-1:2009

Terminology

ABNT NBR ISO 15916:2010

• Basic hydrogen systems security issues

ABNT NBR ISO 14687-1:2010

- Hydrogen fuel Product Specification
- 1st part: All the application, except PEM fuel cells for road motor vehicles

ABNT NBR ISO 16110-1:2010

• Hydrogen generators that utilizes fuel processing technologies

ANBT NBR ISO 17268:2010

• Connecting device for refueling ground vehicles with compressed hydrogen

ABNT NBR/IEC 62282-2:2010

• Fuel cell technology – part 2

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Thank You!

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