

ELETROBRÁS

Centrais Elétricas Brasileiras

CEPEL - Centro de Pesquisas de Energia Elétrica

Hydrogen and Fuel Cell Stationary Applications

Eduardo T. Serra, DSc.

Research Consultant, R&D Directorate

IPHE – International Partnership for the Hydrogen Economy
Rio de Janeiro, March 22-23, 2005

ELETROBRÁS

- ✓ **Established in 1962 to become the federal holding company for electricity generation and transmission;**
- ✓ **Eletrobrás Group companies are responsible for the production of 60% of the electricity consumed in Brazil;**
 - ✓ **Installed capacity 41.8 GW (31 Hydro, 16 Thermal, 2 Nuclear)**
 - ✓ **Transmission lines ~51,000 km**
 - ✓ **Participation on electricity distribution through regional utilities in 6 states.**

ELETROBRÁS

✓ Eletrobrás Group Companies

✓ Generation and Transmission

- ✓ FURNAS
- ✓ CHESF
- ✓ ELETRONORTE

✓ Generation

- ✓ CGTEE
- ✓ ELETRONUCLEAR
- ✓ ITAIPÚ (50%)

✓ Transmission

- ✓ ELETROSUL

✓ Distribution

- ✓ CEAL
- ✓ CEAM/Manaus Energia
- ✓ CEPISA
- ✓ CERON
- ✓ Boa Vista Energia
- ✓ Eletroacre

✓ Research Center

- ✓ **CEPEL**

CEPEL

- ✓ **CEPEL** is the research center of **Eletrobrás** and of its electricity production, transmission and distribution companies.
- ✓ R&D Activities for **Eletrobrás Group Companies** are mainly carried out by **CEPEL**.
- ✓ **CEPEL** was created in 1974 to meet the needs of the rapidly expanding Brazilian electric sector, and today occupies a prominent position in the international scene.
- ✓ **CEPEL** is the largest electric power research center in the Southern Hemisphere.

CEPEL's Mission

- ✓ ***To provide technological solutions for electric power generation, transmission and distribution.***

✓ **CEPEL Activities:**

- ✓ R&D projects, producing prototypes and processes and providing technological and laboratory services for the whole Brazilian power sector.
- ✓ Computer programs to support the operation of the Brazilian electric system, the supervision and control of the grid and the expansion of the sector nationwide.

✓ **CEPEL clients:**

- ✓ **Eletrobrás Group Companies;**
- ✓ **Ministry of Mines and Energy (MME);**
- ✓ **Regional generation, private transmission companies and distribution utilities:**
- ✓ **Electrical equipment manufacturers;**
- ✓ **Brazilian Electricity Regulatory Agency (ANEEL);**
- ✓ **National Operator of the Electric System (ONS).**

Infrastructure

✓ Human resources

- ✓ 145 permanent researchers
- ✓ 169 collaborating researchers
- ✓ 94 specialist technicians.

✓ Laboratories

- ✓ CEPEL has 30 laboratories equipped with modern infrastructure for carrying out research work and tests.

Research and Development

- ❖ **Systems Automation Department:** Development of tools for data acquisition, real time operation of electric systems and disturbance analysis.
- ❖ **Electric System Department:** Development of methods and computer programs to assist in the expansion, supervision, control and operation of the electric power system, within the strict requirements of security and quality criteria.
- ❖ **Department of Special Technologies:** Research and application of technologies directed at the use of materials in electric installations, energy efficiency and renewable sources, including sustainability analysis and economic feasibility analysis.

Research and Development

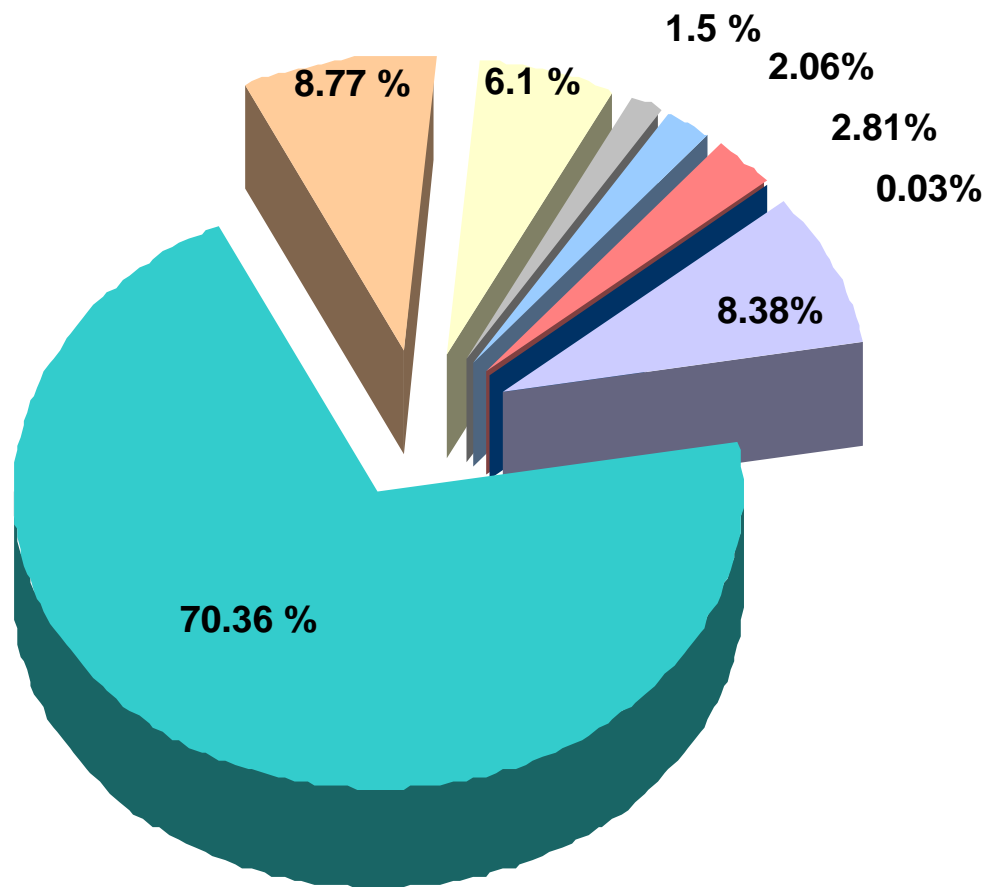
- ❖ ***Installations and Equipment Department:*** Development of technologies to improve equipment used in generation, transmission and distribution of electrical energy (computer models, testing and metering techniques, monitoring and diagnostic systems).
- ❖ ***Department of Energy Optimization and Environmental Issues:*** Development of computer programs for planning the expansion and operation of the interconnected hydro-thermal system. The environmental impacts of new projects are fully taken into account in the multi-criteria expansion planning tools.

Laboratories

- ❑ Analytical Chemistry
- ❑ Corrosion
- ❑ Microscopy
- ❑ Mechanical Properties
- ❑ Insulating Fluids and Paper
- ❑ Electric and Magnetic Properties
- ❑ Refrigeration
- ❑ Lighting
- ❑ Superconductivity
- ❑ Geographic Information System
- ❑ Signal Processing
- ❑ Low-Voltage Devices
- ❑ Photovoltaic Systems
- ❑ Electric Equipment and Magnetic Compatibility
- ❑ Power and Energy Quality
- ❑ Supervision and Control
- ❑ Energy Metering Techniques and Devices
- ❑ Electronic Measurement
- ❑ High-Voltage
- ❑ Corona
- ❑ Pollution
- ❑ Current Impulse
- ❑ Instrument Calibration
- ❑ Reference Center for Solar and Wind Energy
- ❑ High Current
- ❑ High and Medium Power
- ❑ Safety in Electro-electronic Equipment
- ❑ Equipment Diagnostics and Electric Installations
- ❑ Center for the Application of Efficient Technologies

Brazilian Sources of Electricity Production

- Hydro – 68,577 MW
- Gas – 8,547 MW
- Oil – 5,941 MW
- Coal – 1,461 MW
- Nuclear – 2,007 MW
- Biomass – 2,739 MW
- Wind Energy - 29 MW
- Imports – 8,170 MW



CEPEL's Activities on Fuel Cells

- ✓ **Establishment of a Fuel Cell Laboratory for system and hydrogen production performance evaluation;**
- ✓ **Demonstration project - *5 kW PEMFC* with *Natural Gas Reformer* for hydrogen production (together with CHESF);**
- ✓ **Participation in a project (Ministry of Science and Technology funded) for the construction of an *Ethanol Reformer* for hydrogen production;**
- ✓ **Participation in the Ministry of Mines and Energy (MME) Working Group for the elaboration of the Brazilian Policy on Hydrogen.**

5 kW PEM Fuel Cell and NG Reformer



Eletrobrás and CEPEL's Vision

- ✓ **Fuel Cells may have an important role for the expansion of distributed generation in Brazil;**
- ✓ **The Brazilian industry has already technical capacity for manufacturing stationary Fuel Cells;**
- ✓ **Cost reduction of FC depends on large scale production;**
- ✓ **There is a network of Universities and Research Centers capable to support a Policy for Hydrogen use in Brazil;**

Eletrobrás and CEPEL's Vision (cont.)

- ✓ **Brazil should, through the government development agencies, induce and promote R&D on hydrogen generation from biomass (ethanol) and from electrolysis;**
- ✓ **An Integrated Electrical System, associated to the Hydro Generation, places Brazil in privileged position for hydrogen production from electrolysis;**
- ✓ **The Brazilian experience on ethanol production for automotive use legitimate the R&D investments to obtain hydrogen from ethanol.**

Thank You

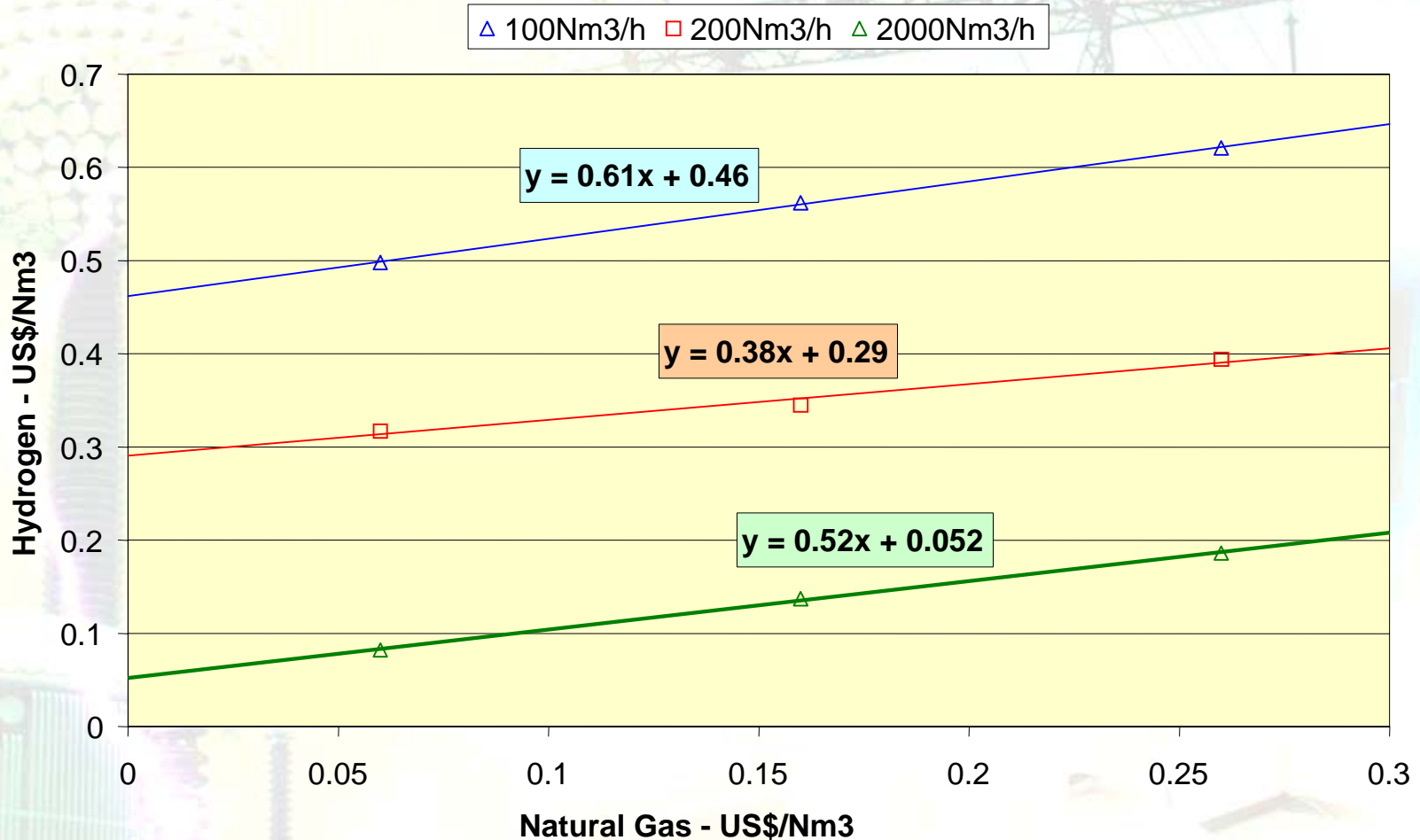
Dr. Eduardo T. Serra
Research Consultant
R&D Directorate

CEPEL – Electric Power Research Center
ELETROBRÁS GROUP

etserra@cepel.br

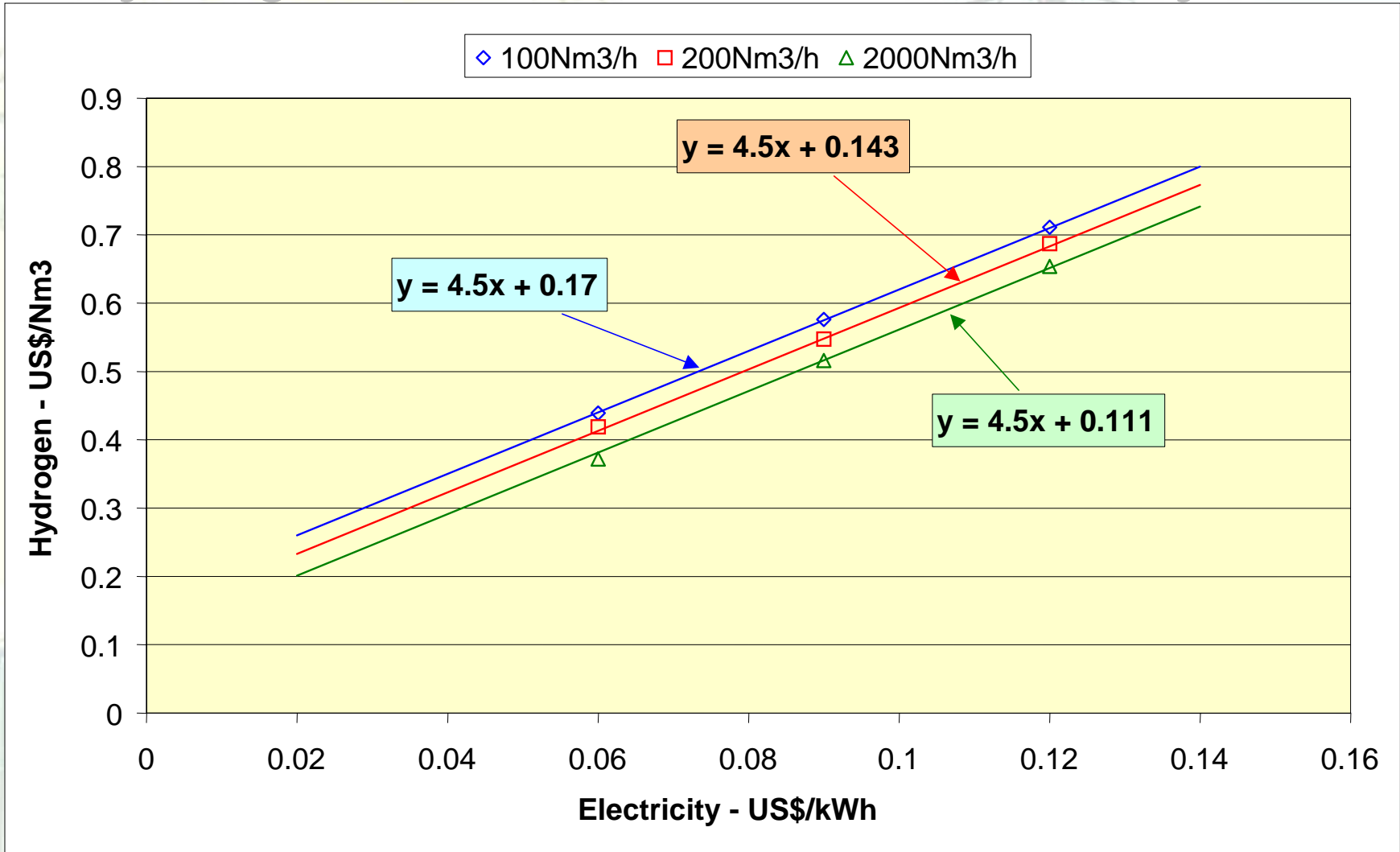
www.cepel.br

Hydrogen Production from NG



Adapted from: Simader, G. - "Fuel Cell Technologies for Hydrogen (Part I: Basic Principles)".
Lisbon, 15-19 April 2002

Hydrogen Production from Electricity



Hydrogen Production by Electrolysis (DOE Targets)

Target	Cost (US\$/kg)	Cost (US\$/Nm ³)
Present	6,10	0,55
2005	4,80	0,43
2010	3,50	0,32

Hydrogen Production by NG Reform (DOE Targets)

Target	Cost (US\$/kg)	Cost (US\$/Nm ³)
Present	5,00	0,45
2005	3,00	0,27
2010	1,50	0,14

Fuel	LHV (per mass unit)	LHV (per volume unit)	Specific Mass	Reference Price	US\$/GJ
Hydrogen	119.600 kJ/kg	9.967 kJ/m ³	0,083 kg/m ³	US\$1/m ³ to US\$6/m ³	100 to 600
Natural Gas	49.694 kJ/kg	35.780 kJ/m ³	0,72 kg/m ³	US\$0.17/m ³ to US\$0.53/m ³	5 to 15
LPG	46.044 kJ/kg	100.836 kJ/m ³	2,19 kg/m ³	US\$10/bottle with 13kg	16
Ethanol	26.378 kJ/kg	21.334 kJ/liter	0,809 kg/liter	US\$0.65/liter	30
Gasoline	44.173 kJ/kg	32.776 kJ/liter	0,742 kg/liter	US\$0.80/liter	24
Diesel	43.335 kJ/kg	36.922 kJ/liter	0,852 kg/liter	US\$0,32/liter	12