Latin America Thematic Network on Bioenergy - Lamnet

3rd Project Workshop - Brazil

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Panel Discussion: Challenges and opportunities of ethanol based fuel cells

Newton Pimenta Neves Jr.
CENEH

National Reference Center for Hydrogen Energy

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www.ifi.unicamp.br/ceneh ceneh@ifi.unicamp.br

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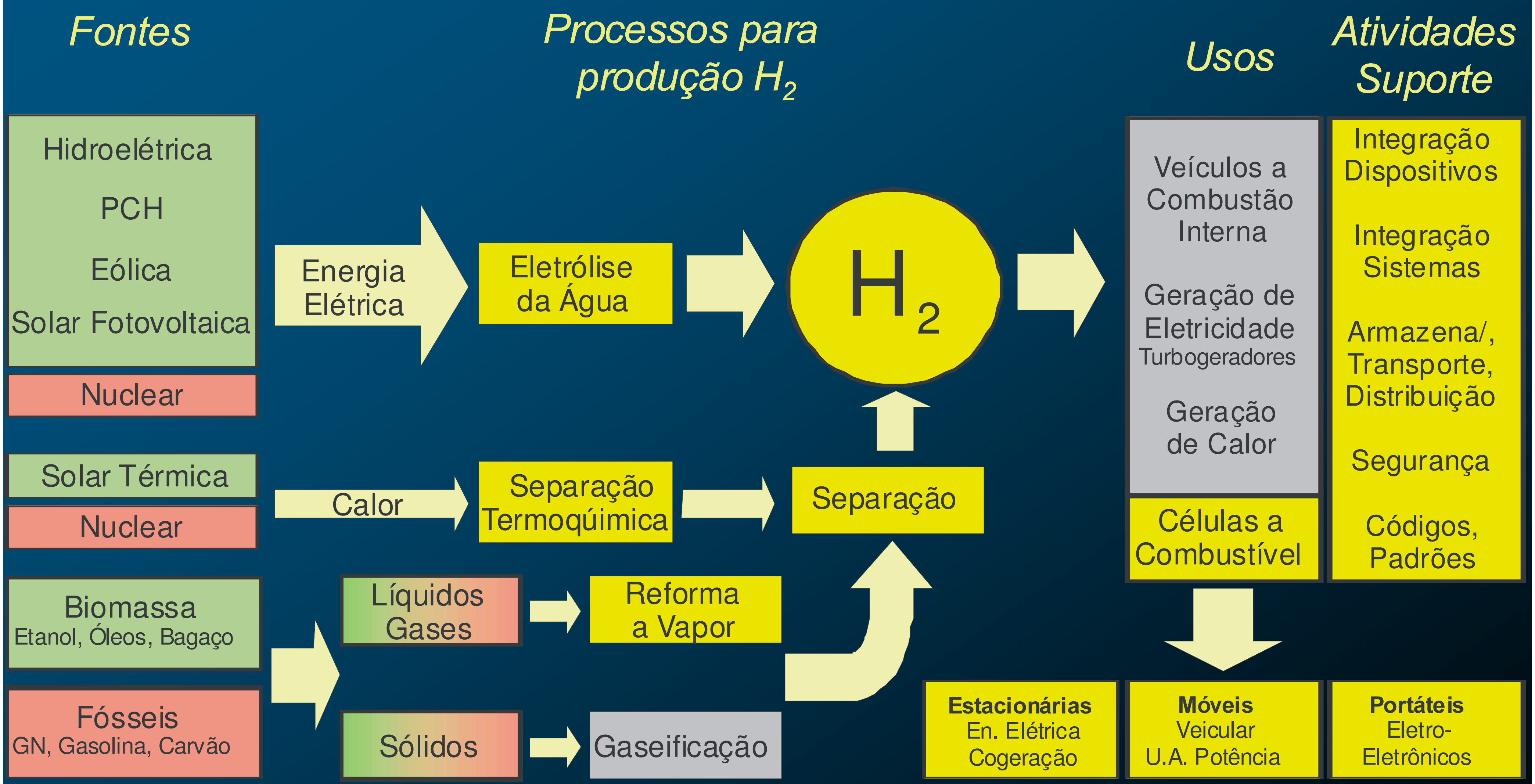
National Reference Center for Hydrogen Energy

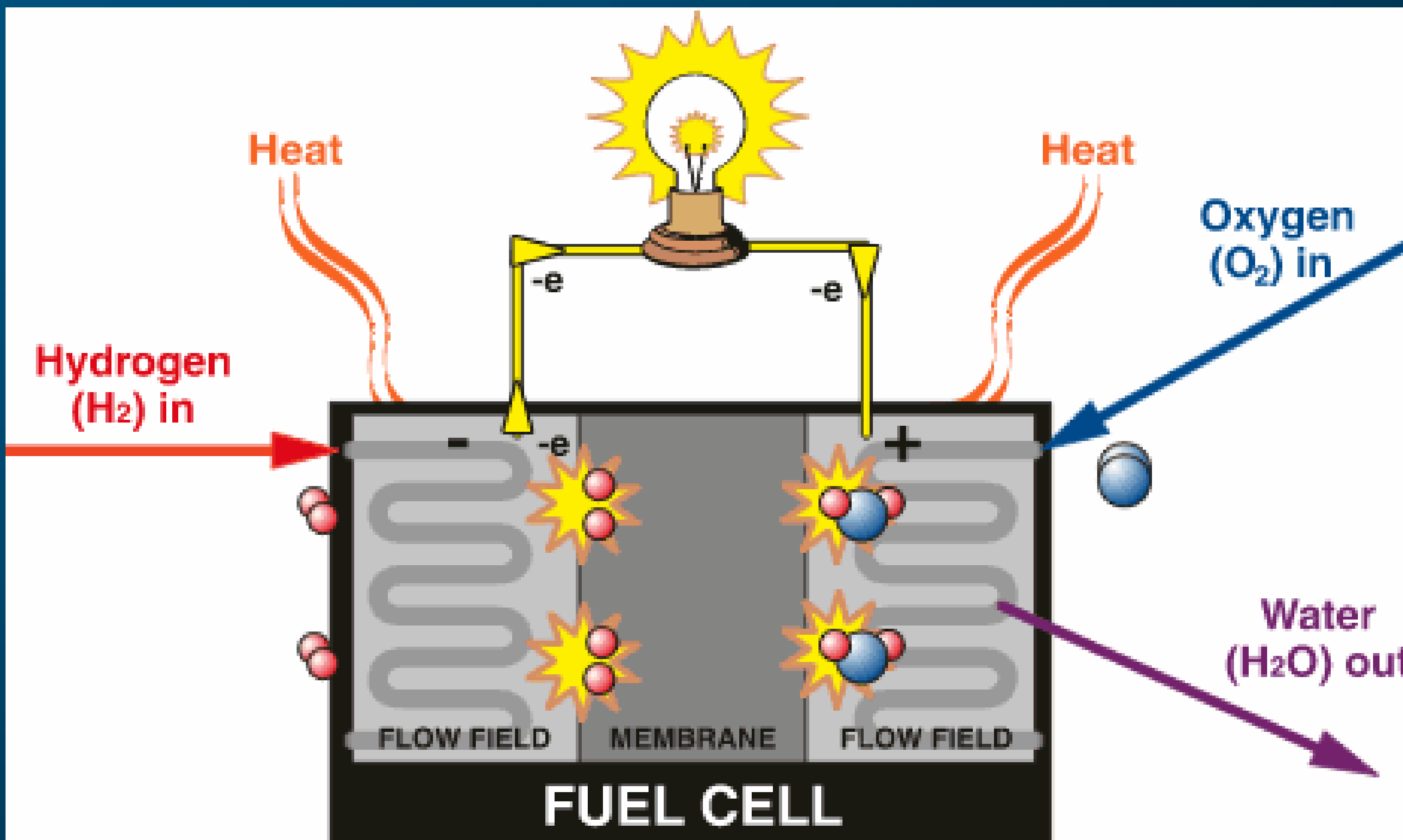
- CENEH was launched – Mars, 2001
- Location: University of Campinas, São Paulo State
- Objectives:
  - Energetic uses of Hydrogen / Fuel Cells
  - Collection and diffusion of information
  - To perform researches and studies
  - Promotion of events of interest
  - Assistance for energy policy formulation

H_2 for energetic uses



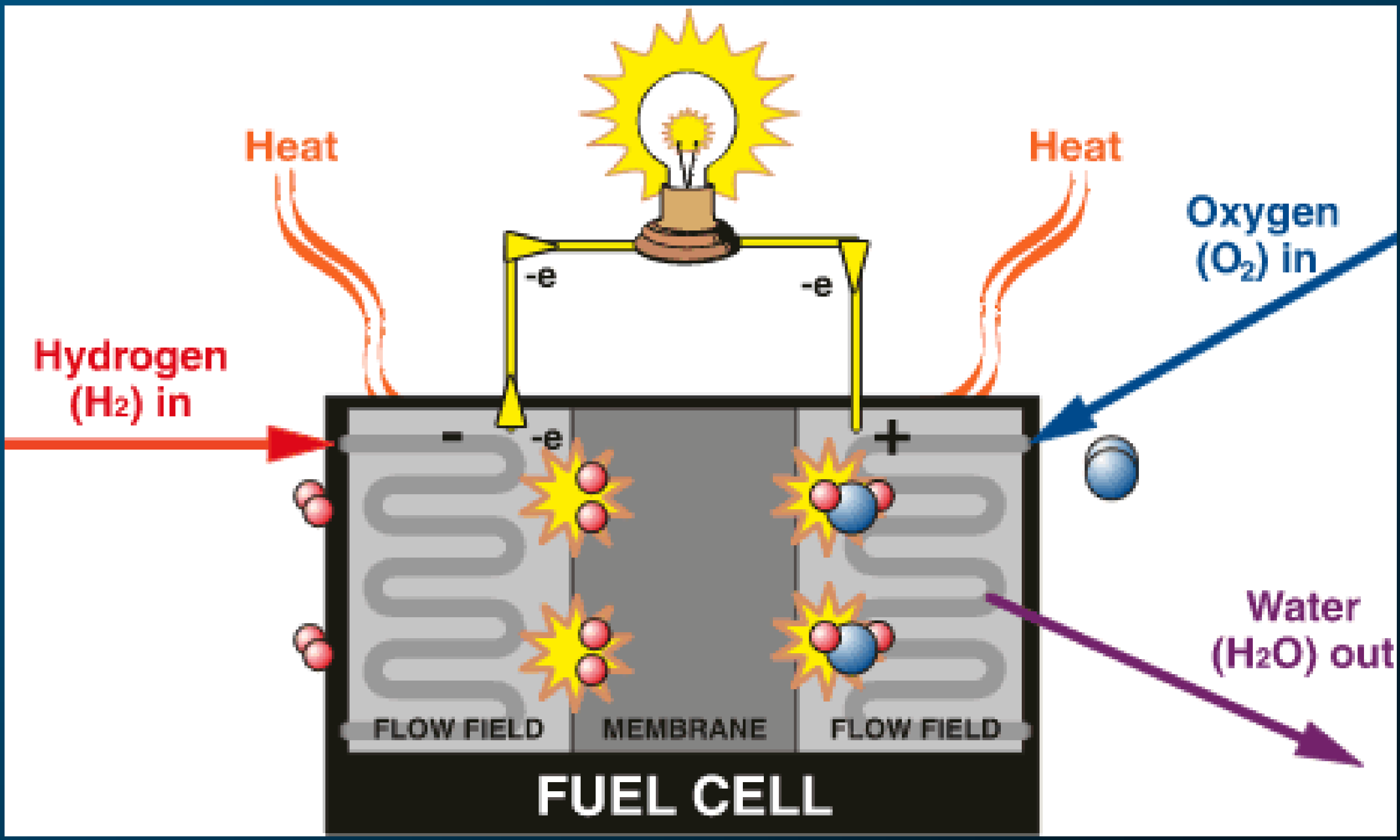
Áreas de atuação do CENEH em amarelo

Fuel Cell



Source: HPower, USA

Fuel Cell



Source: HPower, USA

Fuel Cells: types and present stage

Cell / Electrolyte	T_{max} (°C)	Fuel	Stage	Uses
Polymeric Electrolyte	50 80	NG / Methanol reforming	Prototypes	T DG
	60 130	Methanol direct	Prototypes	T DG
	50 80	Ethanol reforming or direct	R&D	T DG
Alkaline	50 200	H_2	"Comercial"	T S
Phosphoric Acid	190 210	Natural Gas reforming	Comercial 225 in 2002; 100 in 1997	Heat DG
Molten Carbonate	630 650	Natural Gas internal reforming	Prototypes	CG DG CoG
Solid Oxide	700 1000	Natural Gas internal reforming	Prototypes under development	CG DG CoG

Fuel Cells: Advantages

- Direct conversion of chemical energy into electric energy
- Conversion efficiency superior to that of thermal devices
- No moving parts – low noise levels
- Modular capabilities facilitate adjustment to the load and increase reliability (from W to MW)
- Quick response for load changes (PEFC, PAFC)
- Very low or zero emissions of SOx, NOx, CO_2 and organic compounds

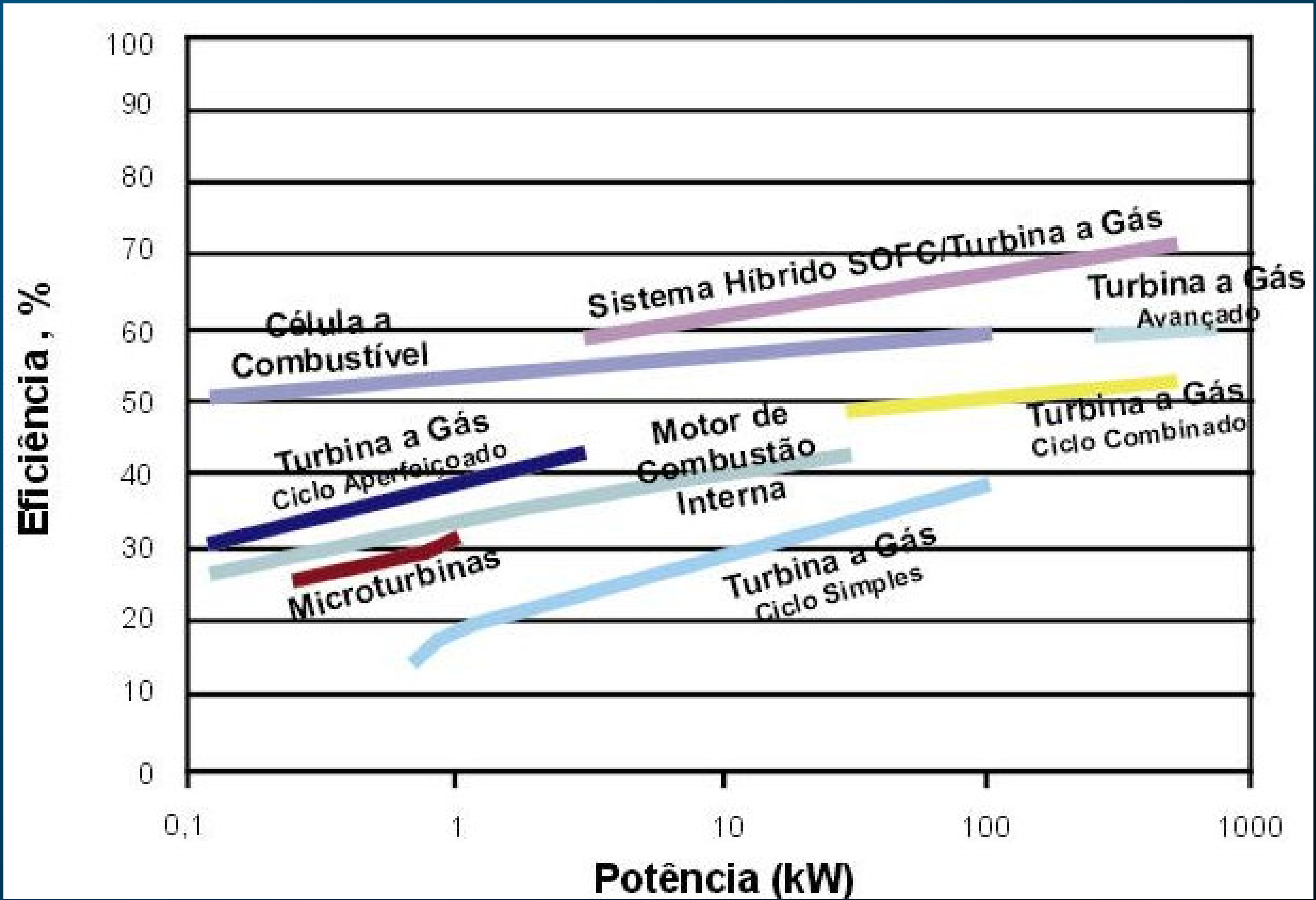
Fuel Cells: Disadvantages

- High costs
- Lifetime and recyclability
- Hydrogen production / distribution infra-structure (or other fuels)
- Noble metal employment – Platinum in some types of cell (PEFC, PAFC)
- Little public awareness about the technology

Fuel Cell Efficiency

- Efficient electric power generation:
  - Fuel cells are not limited by Carnot Cycle – direct conversion of chemical energy into electric energy
  - Cogeneration increases the efficiency to >70% in MCFC and SOFC
- Hydrogen provides the highest efficiency

Estimated Efficiency for Power Generation Systems



Source: Fuel Cell Handbook, DOE, USA

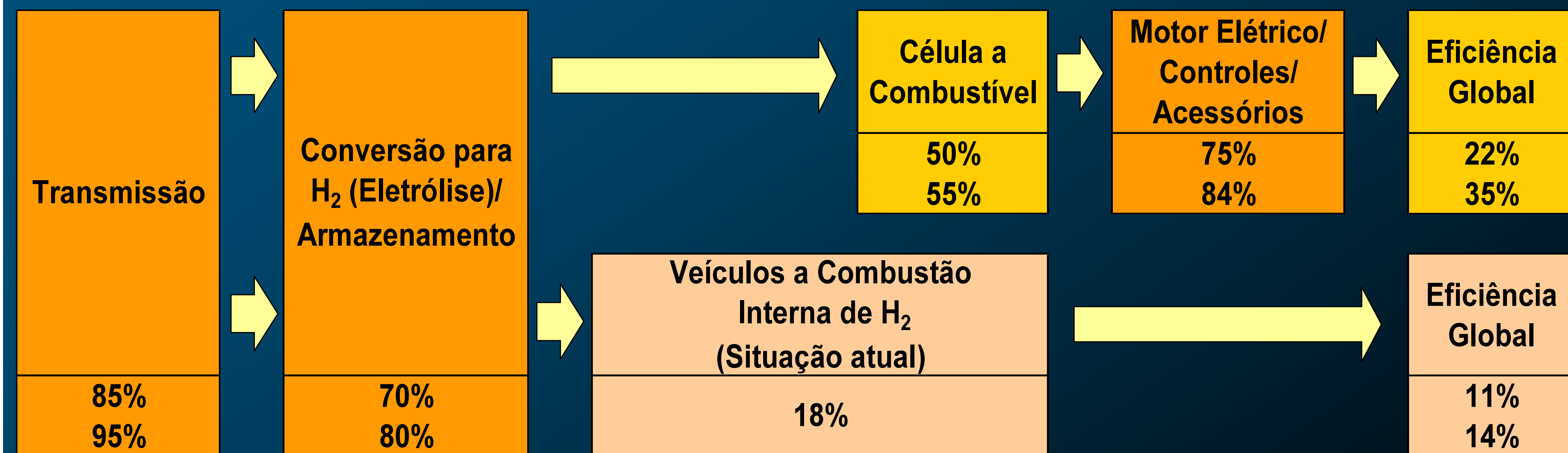
Well-to-Wheel Efficiency: Automotive Vehicles

Energy Source: Oil

Extração	Processamento da Gasolina/ Distribuição	Conversão		Motor Elétrico/ Controles/ Acessórios	Eficiência Global
96%	88%	Reforma Autotérmica (produz H_2): 75% – 80%	Célula a Combustível: 50% – 55%	75% – 84%	24% – 31%
96%	88%	Veículo Híbrido Combustão Interna de Gasolina (Motor Estacionário Otimizado): 40% – 42%		75% – 84%	25% – 30%
96%	88%	Veículo a Combustão Interna à Gasolina (Situação atual): 18%			15%

Well-to-Wheel Efficiency: Automotive Vehicles

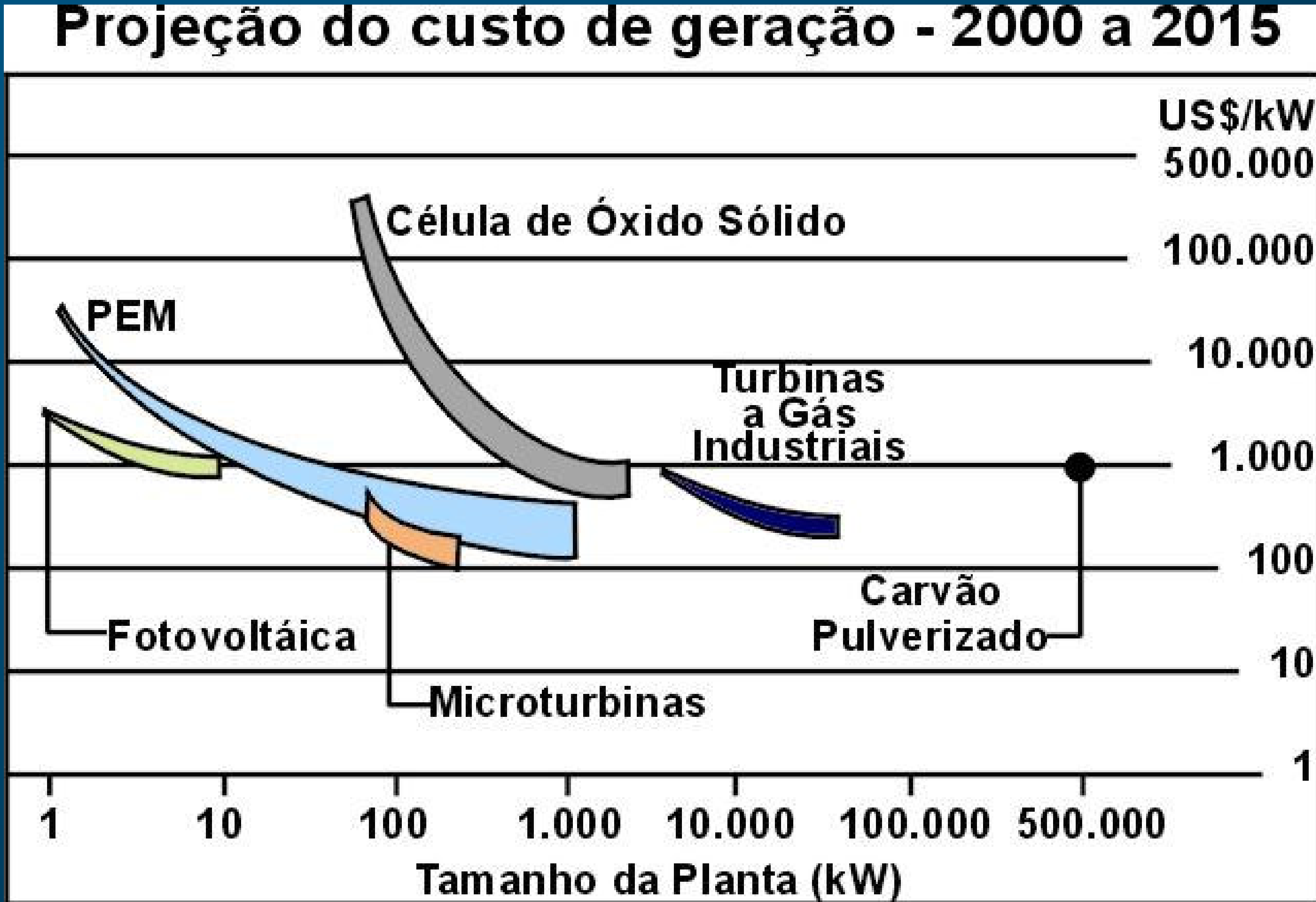
Energy Source: Wind power, Photovoltaic, Hydropower



GM study

- On a well-to-wheel greenhouse gas emissions basis, the best use for natural gas was to reform it to obtain hydrogen for use in hydrogen FCVs.
- The use of hydrogen from natural gas in internal combustion engines actually produces poorer well-to-wheel results than do conventional gasoline engines.
- When natural gas was used to produce methanol for an on-board reformer FCV, no well-to-wheel benefits were seen relative to conventional gasoline or diesel IC engine vehicles or gasoline reformer FCVs.

Competing technologies also evolve



Source: Electric Power Research Institute

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Distributed Generation System based on Fuel Cells

PC25 unity - UTC
Fuel Cells, USA (formerly IFC), 200 kW

COPEL (Paraná-Br)
Electricity for the computer center

Capital costs: US$ 4,750
Ideal: US$ 1,710

NG consumption:
247 m^3 /MWh

Operation costs
(NG and maintenance):
R$ 205 / MWh

Electric Efficiency:
40% (HHV)
37% (LHV)

Source: LACTEC

NECAR 5: methanol and room in the trunk DaimlerChrysler

Fuel Cell:
PEM – Ballard (75 kW)

Fuel: Methanol

Reformer inserted in the double floor:
50% smaller, 300 kg lighter

Max. speed: 150 km/h

Capacity: 4 adults

Test (2002): 5,250 km in 12 days

Average speed: 62 km/h

Repairs: fuel filter, belt and water reservoir

Honda FCX
1st vehicle certified in the US

Fuel Cell:
PEM - Ballard (78 kW)
Honda Ultra Capacitor

Motor AC synchronous
Max. power: 80 hp (60 kW)

Fuel: Hydrogen (gaseous)
Tank: 157 L, 345 bar

Max. speed: 150 km/h
Range: 355 km
Capacity: 4 adults

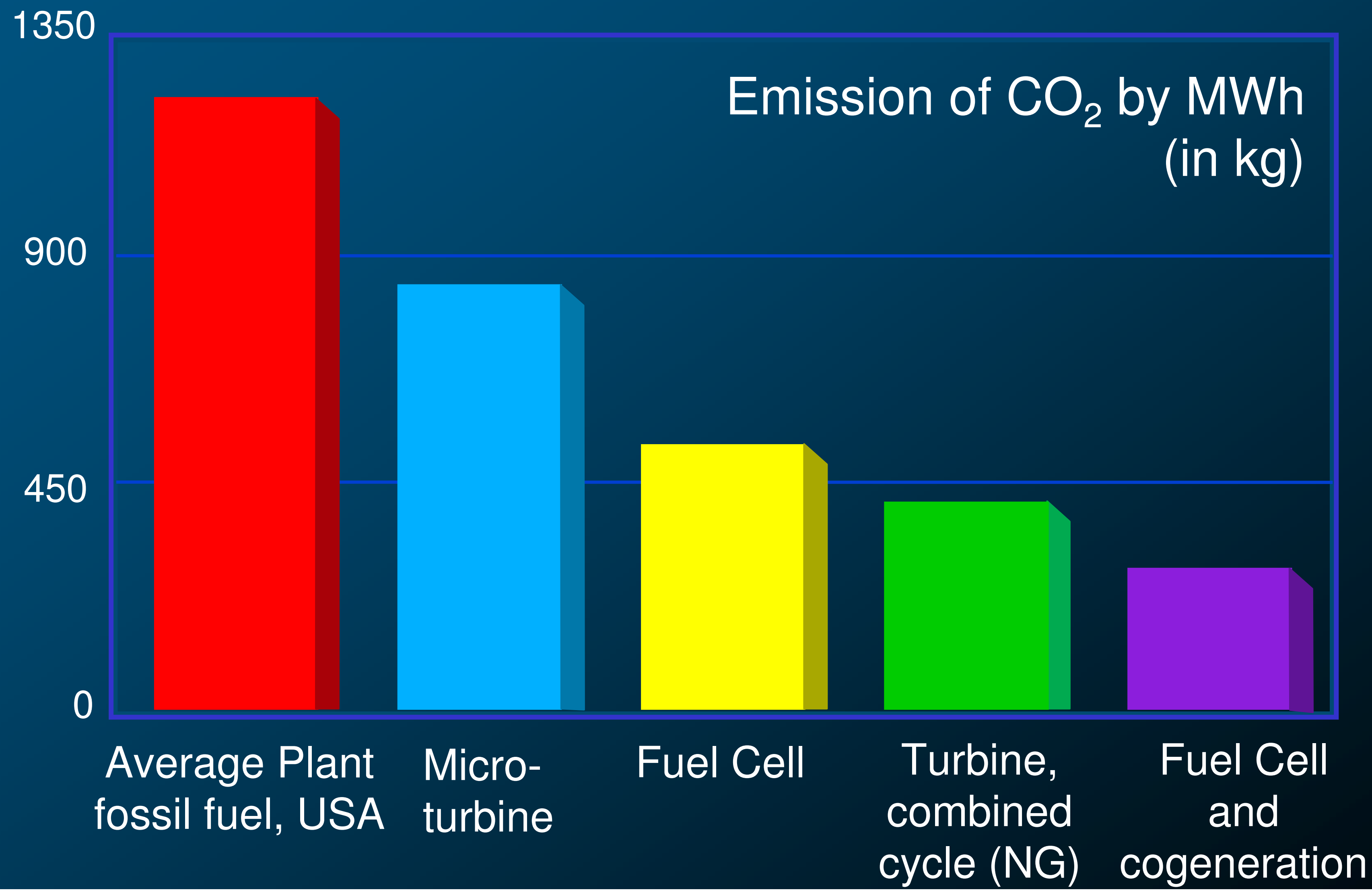
Nebus
Mercedes-Benz Prototype

- Fuel cell bus prototype - Germany
- Power: 250 kW (10 stacks - 335 hp)
- Fuel cell system occupies the same space as the original engine and transmission
- The fuel cells run on hydrogen and oxygen

Environmental Aspects

- When evaluating costs associated to emissions, technologies that use H_2 and renewable energies as ethanol will take advantage.
- Devices operating under thermal cycles usually are less efficient and more pollutant than systems with fuel cells.
- Brazilian case: good perspectives in associating ethanol with fuel cells (direct use or H_2 from reforming)

Environmental Aspects: Global Warming



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Fuel Cell Investment

Investor	Description	Investment	Period
USA (except defense) (DOE)	R&D and demo programs H2 and fuel cell	US$ 150 mi	1999
DOE: FreedomCAR DOE: SOFC and MCFC	Office of En. Effic. and R.E. Office of Fossil Energy	US$ 162 mi US$ 49,5 mi	2002 (proposal)
State investment: Ohio – USA	R&D, demo, training, loans (low interest)	US$ 103 mi	2002 to 2005
Fuel Cells Canada: government and companies	R&D and demonstration programs	US$ 19,5 mi	2000 to 2002
European countries (H_2 French Association)	European countries	US$ 190 mi GR: 90 FR: 35	2000
Industrial Investment: DaimlerChrysler	Private investment	US$ 1500 mi	2000 to 2004

Investments superior to US$ 2,2 billions from 1999 to 2005

Brazilian Program on Fuel Cell Systems

- Ministry of Science and Technology – MCT by means of the Center of Management and Strategic Studies - CGEE
- A study was commissioned to verify the Brazilian situation:
  - Several projects (not linked) of R&D in fuel cells
  - Demonstration projects
  - Small enterprises

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Brazilian Program on Fuel Cell Systems

- R&D in Fuel Cells comprise several areas of knowledge, which leads to the necessity of coordination of Investments and R&D projects: Program
- To develop components (instead of equipment) can be a good strategy
- Program underwent a public consultation (Ago/Sep 2002)
- Program was launched in November 14, 2002

Programa Brasileiro de Sistemas de Células a Combustível

- Portaria 731 do MCT - 14 de novembro de 2002
  - Art. 1º- Instituir o Programa Brasileiro de Sistemas Célula a Combustível - PROCaC, com o objetivo de promover ações integradas e cooperadas, que viabilizem o desenvolvimento nacional da tecnologia de sistemas célula a combustível.
  - Art. 2º- O Programa Brasileiro de Sistemas Célula a Combustível será coordenado pela Secretaria de Política Tecnológica Empresarial do Ministério da Ciência e Tecnologia - MCT.
  - Art. 3º- Para viabilizar o Programa Brasileiro de Sistemas Célula a Combustível, o MCT coordenará uma rede de pesquisa e desenvolvimento tecnológico, cujos representantes dos partícipes interessados serão designados no prazo de 60 dias.
  - Art. 4º- Esta Portaria entra em vigor na data de sua publicação.

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Final Considerations

- News about fuel cells may imply that the technology is ready for commercialization and that fuel cells may be easily found in the market
- Few models are commercially available
- Costs are still very high
- Materials may be difficult to be obtained: cost increase, scarceness or strategic reasons

Final Considerations

- Ethanol: production and distribution infra-structure must assure that the fuel is free from contaminants that poison fuel cells.
- As the cell lifetime increases, the effects of micro-contaminants will be better known (H_2 or ethanol).
- Standards should be developed for handling and storing H_2 and ethanol.

Final Considerations

- Market niches may be profitable if well exploited.
- Ceramics and catalysts for fuel cells and reformers.
- Back-up systems and portable applications, in which the efficiency and durability are not necessarily high, constitute an important niche for direct fuel cells.

The power of an image

A cleaner source of energy is coming down the pipe.

Source: Texaco

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THANK YOU