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Topics on PEM Fuel Cell for Micropower - Brazilian Experience

M.Linardi
Instituto de Pesquisas Energéticas e Nucleares
Comissão Nacional de Energia Nuclear
Travessa "R" n° 400, Cidade Universitária - CEP 05508-900, São Paulo, Brazil
e-mail: mlinardi@net.ipen.br

The need for more efficient energy conversion is presently evident as the world fossil fuel sources become scarcer and the cost of the fuels rises. Moreover, the urgent necessity of reducing the pollution in large urban centers imposes the use of non-polluting fuels, like hydrogen and renewable primary fuels in large scale.

Also fuel flexibility is required in the near future. According to a recent review from a fuel company "The question of fuel choice, for fuel cell vehicles remains an open one". For stationary applications the question is also pertinent. Research for the best solution may lead to the definition of more convenient local options. The "best" fuel solution is strongly influenced by the local conditions in the country, or region, being considered.

Fuel cells have shown to be an interesting and very promising alternative to solve the problem of clean electric power generation with high efficiency, including fuel flexibility. The fuel fed battery, known as fuel cell, producing as "waste" just water and heat, is one of the most promising technologies for this century to deal with energy sustainability. Various practical fuel cell types are shown in table 1.This approach can be applied for stationary electrical energy production as well as for electrically driven vehicles with low (or zero) emission.

Table 1: Fuel Cell Types

FC-Type	*Abbreviation*	*Temperatures*	*Uses*
Alkaline	AFC	80-200°C	Space vehicles
Polymer Electrolyte	PEFC	80-100°C	Stationary;Buses;cars
Direct Methanol	DMFC	80-100°C	Buses; cars; cell phones
Phosphoric Acid	PAFC	200°C	Stationary; heating
Molten Carbonate	MCFC	600°C	Stationary;Co-generation
Solid Oxide	SOFC	800-1000°C	Stationary;Co-generation

The mainly reactions involved in a acid fuel cell operated on H_2/O_2 are:

Anode: $H_2 \rightarrow 2\,H^+ + 2\,e^-$ $E^0 = 0{,}0$ V vs. NHE

Cathode: $\frac{1}{2}\,O_2 + 2\,e^- + 2\,H^+ \rightarrow H_2O$ $E^0 = 1{,}23$ V vs. NHE

Total: $H_2 + \frac{1}{2}\,O_2 \rightarrow H_2O$ $U_{th} = 1{,}23$ V

In the second electrical century, technological, economic, and mainly environmental aspects should be considered in energy planning. Reliability is another key word concerning the emerging digital economy. The resulting energy system goes toward a more small-scale decentralized model, called micropower. Fuel cell technology fits all requirements for this new model. Moreover, micropower may be most beneficial in the developing world. Figure 1 depicted a simplified schema of a residence with its own electrical and thermal energy-producing device (fuel cell) illustrating the micropower concept.

Among all practical types of fuel cells, considering their main features (advantages and disadvantages) the Proton Exchange Membrane Fuel Cell type (PEMFC) technology is of great interest due to its characteristics. Considering this technology, the fuel choice is very flexible and the work on this subject is abundant. Hydrogen is the best fuel choice, related to cell efficiency. In large scale, however, this approach is not available now, as shown in Figure 2, but water electrolysis has to be considered in a scenario concerning vanishing fossil fuel sources.

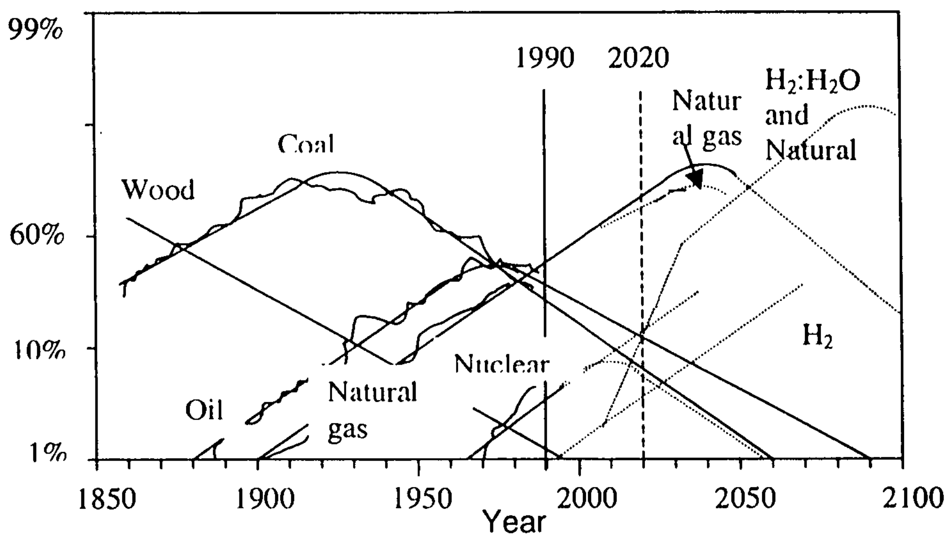

Figure 2: Primary Energy Substitution Model

The IPEN (Instituto de Pesquisas Energéticas e Nucleares) at São Paulo, Brazil has started a research group on fuel cell in 1998. The developments are restricted to stationary applications aiming micropower. Brazil has also special interest in ethanol oxidation (also as primary fuel), as ethanol is already used in transportation and countrywide produced and distributed. The activities are summarized as:

- Optimization of operation parameters of single Fuel cell;
- Development of an innovative producing method of GDE (Gas Diffusion Electrode) and MEA (Membrane Electrode Assembly), (5X5) cm^2 and (12X12) cm^2 electrode surface;
- Electrocatalysis: Fundamental Research; Development of a normalization method for comparison analysis;
- Development of new nano-dispersed electrocatalyst systems for anodes with better CO-tolerance;
- Basic studies of a cheaper nano-catalyst producing process, via well-defined clusters.

Also a low powered PEMFC-prototype development (together with ELECTROCELL) belongs to the program features at IPEN, as shown in Figure 3.

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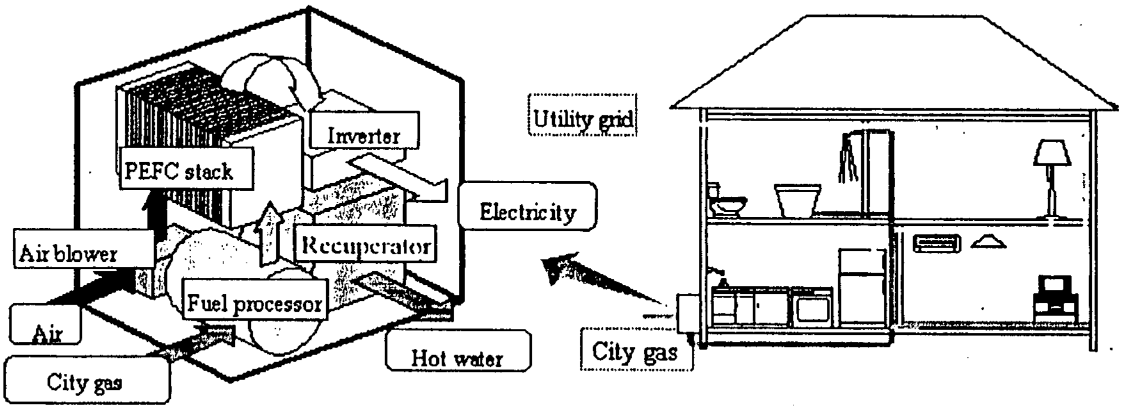

Schematic configuration of residential PEFC cogeneration

Figure 1: PEMF for micropower.

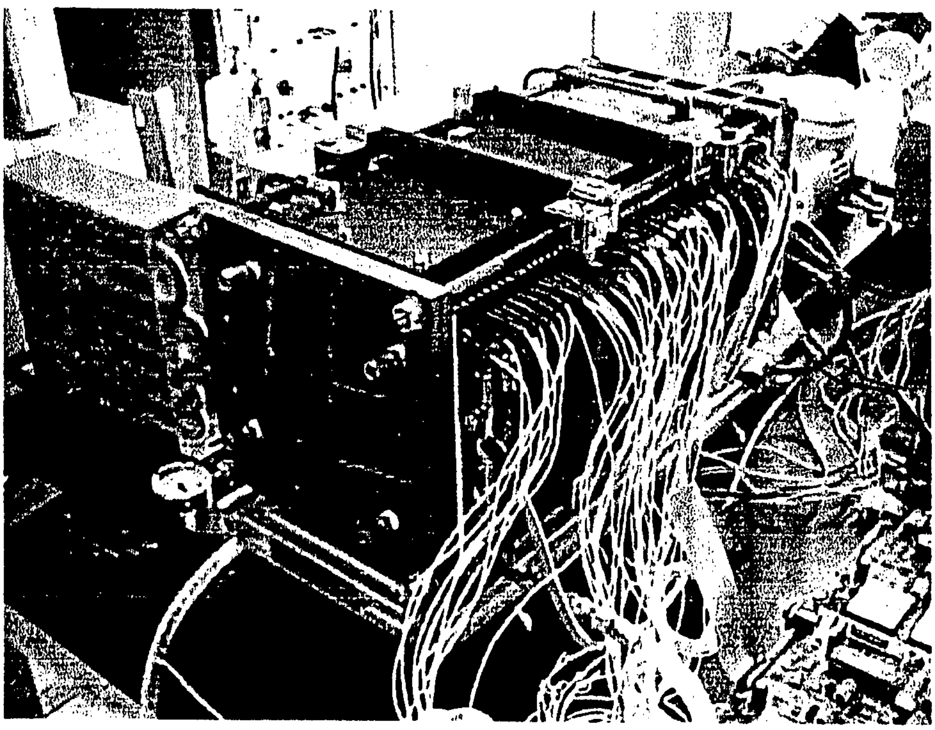

Figure 3: 3 kW – PEMFC from Electrocell

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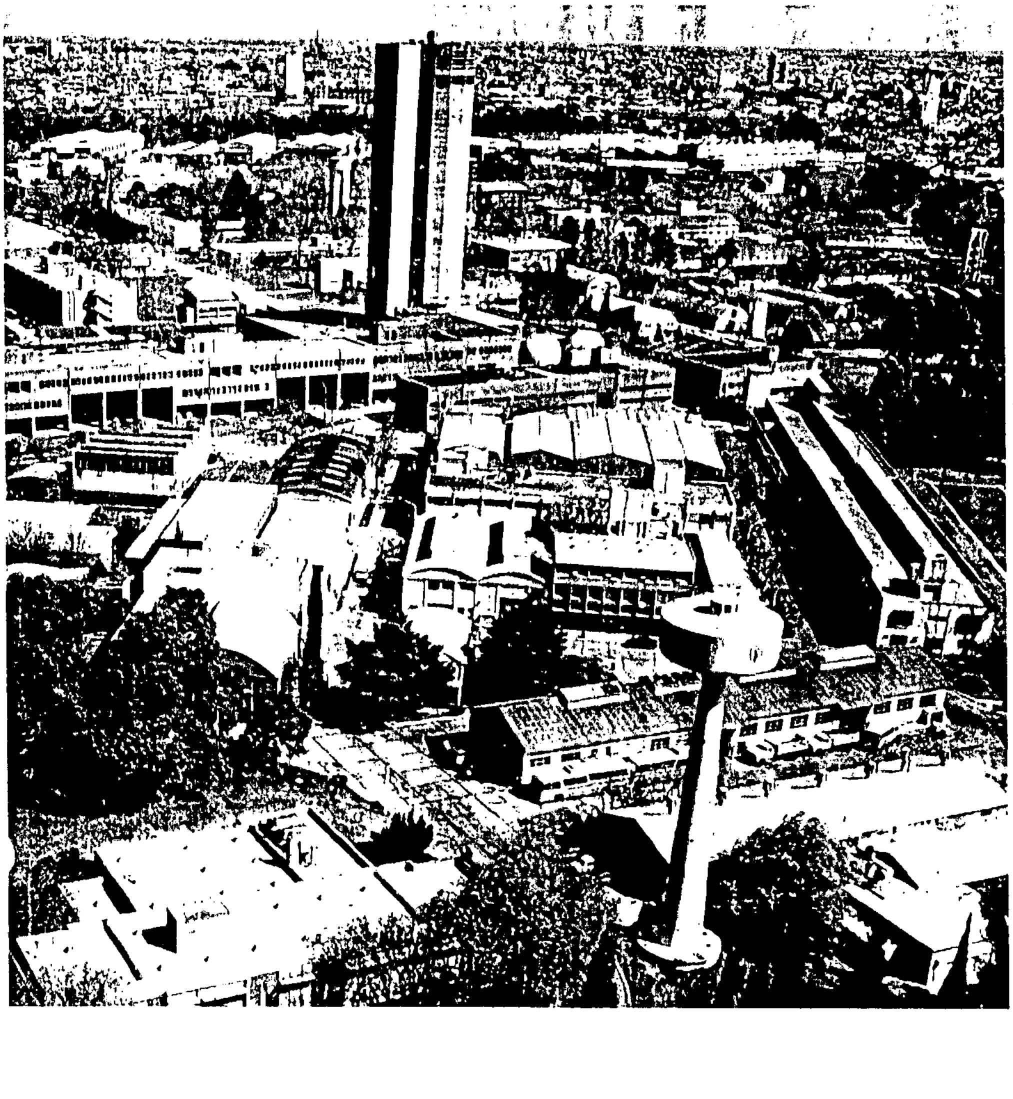

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