Strategies for the Commercial Introduction of Modular Low Power Fuel Cells

P.E. de Miranda, A. Laufer, H.V. de Miranda

This document appeared in

Detlef Stolten, Thomas Grube (Eds.):
18th World Hydrogen Energy Conference 2010 - WHEC 2010
Parallel Sessions Book 5: Strategic Analyses / Safety Issues / Existing and Emerging Markets
Proceedings of the WHEC, May 16.-21. 2010, Essen
Schriften des Forschungszentrums Jülich / Energy & Environment, Vol. 78-5
Institute of Energy Research - Fuel Cells (IEF-3)
Forschungszentrum Jülich GmbH, Zentralbibliothek, Verlag, 2010
ISBN: 978-3-89336-655-2

Strategies for the Commercial Introduction of Modular Low Power Fuel Cells

Paulo Emílio de Miranda, **Alfredo Laufer**, Universidade Federal do Rio de Janeiro, Brazil
Hugo Villela de Miranda, EnergiaH, Brazil

Abstract
The reality of the infrastructure in emerging economies brings the opportunity to build up a hydrogen compatible economy. For the Brazilian case, the fast development in many fields coexists with a considerable amount of potential renewable fuels available. Costs of energy distribution and of power grid maintenance throughout a continental size country may lead to a distributed generation system based in a diversified fuels matrix. This pathway drives attention to simpler low power fuel cell devices, with easier maintenance procedures, friendlily integration with small power demands, and the capability of being applied separately or integrated to deliver higher power demands. Big cities and small distant agriculture based locations, such as Rio de Janeiro or rain forest extractive communities, could be able to produce fuel and energy in their own infrastructure projects. This article presents a market roadmap for the commercial introduction of direct oxidation type solid oxide fuel cells in Brazil, specifying fuel cell technological features and the specificities for each type of application, either in grid connected or in stand alone low power electric energy generation.

1 Introduction

A reliable source of Energy is one of the most important conditions to support development and growth. The distribution of energy in a continental nation such as Brazil is an expensive and difficult challenge. Local energy production is viewed as the best alternative to provide or to balance energy supply for small and standard demands, such as, small villages and extractive or agricultural communities. Local production may become of economic interest, mostly due to the costs of building, expanding and doing maintenance work on transmission lines of energy.

The Federal Government, using the regulatory agency for the electric market, has imposed some goals for the companies that are authorized to generate, transmit or supply electric energy in Brazil. To regulate those goals, the Federal Energy Regulatory Agency (ANEEL, in Portuguese) has made the Resolution nº 83/2004, establishing the conditions for being accepted as part of a program to generalize the energy supply.

Some developing countries, such as Brazil, still need to build an important part of the necessary infrastructure to support their economic growth. These characteristics allow the development of a multi source energy generating system and give opportunity to implement and test fuel cell devices. To develop these markets there are some opportunities and difficulties. We began to demonstrate some of those opportunities, analyzing initially the

technical capability of the country in that area, understanding some configurations and elements necessary for the technology implementation and exploring some initial markets that are already able to receive this technology.

2 Technical Development in Brazil

Most part of the technical development is been made in the Federal Universities. There are no more than 3 companies developing solid oxide fuel cells and, those companies, have their development being made in cooperation with universities or public research centers. The reason for this is strongly based in the federal system of tax regulation in Brazil that provides public universities and research centers with technical and economic resources allowing companies to have a lower cost of research when in cooperation with them.

In order to support a market appropriation of this knowledge generated in the research centers, the developing countries need to invest more money and effort in generating an environment that articulates the R&D programs, research centers and industries, creating networks capable of assimilating, in a systemic way, new emerging technologies, generating new competences and abilities [1].

Furmana et al. [2] support that a nation infrastructure driven for innovation requires a series of human and financial factors. Those are based in the public polices for innovation in science and technology and the inherited economic sophistication.

Driven to those ideals, a national solid oxide fuel cells development network for (PaCOS, in Portuguese) was created in 2004. The network managed to generate human resources and some of the research groups achieved excellent results focusing in developing critical parts, such as the anode.

Important advances have been made recently on the development of parts, balance of plant systems and new materials for anode that support the direct oxidation of ethanol [3]. Those developments were facilitated by the more flexible federal regulations, with a good contribution from the law 11.196 [4], which established fiscal benefits for the private companies that invest in technology development in Brazil.

3 The Market

The electric market in Brazil possesses regulatory impositions in three different segments, the generation, the transmission and the distribution to the consumer. There are different companies for each segment, which are integrated or not in each region. All three companies or are obliged to invest in new technologies by contract. The distribution company, the one responsible for providing energy to the final consumer, has to attend some specific goals for energy distribution. This generates a market for distributed generation in Brazil.

Rural electrification was the biggest challenge. The problem was well attacked within the Program “Luz para Todos” (light for everyone) financed by the Federal Government, which imposed a tax in every single electric bill in Brazil to support the program costs, estimated for the year of 2009 in R$ 8.8 billions, having invested R$ 9.3 billion in 2008. This Program managed to attend the majority of the non-connected residences, but in order to maintain those transmission lines or to expand the capacity for new demands nearby the existing

ones, required by the demand´s natural organic growth it will be necessary to expand the capacity of the transmission lines or to develop distributed generation.

The Program faced an organic growth of approximately 168.000 new connection points in 2009. To this number one has to add the demand for an expansion of the power capability to support small agro-industries. It is estimated to be at least 3.8% per year, based on an universe of 2 million new connection points achieved by the Program. This points out to a demand of 244.000 new connection points or more power yet needed on low power connection points. The growth rate of 3.8% is based on the average expansion of the domestic product for the period 2003-2007 [5].

The installation of new transmission lines or the expansion of the capacity of the existing ones is viewed as the probable solution to solve this problem. To address this issue, one should take into account the actual cost for building low power transmission lines that reached ~ R$26,000.00 per km in 2009. In this scenario, the admitted commercial target price of a fuel cell system may reach ~ US$ 3,000.00 per kW, taking into account a 2kW solid oxide fuel cell. This allows expediting the commercial initialization, considering that the usual fuel cell average commercial target price of US$1,500.00 per kW will no longer be an impeding barrier.

The application of small generation equipments has been the option in many cases. Borges and Carvalho [6] studied a typical situation for the most of the population that has no electric energy in their communities or houses. One of the most important factors is the fuel availability. Solar and wind based powers are conventional options but they depend on an energy storage system that presents problems with the life cycle of the batteries and the irregularity of the generation.

The ethanol production and distribution in Brazil is well established in every Brazilian State, both in large industries and in small familiar agro-industry production. Figure 1 shows the steep growth of the ethanol participation in the Brazilian Energy Matrix for 2009. For the first time products derived from sugar cane have overcome the hydroelectric energy generation.

Considering supplying the energy with low power fuel cell devices connected with the low power transmission lines already installed by the Program may be a way to provide the energy needed by small communities, offering any surplus energy to the grid. To make this a real opportunity, a new anode technology was co-developed by Coppe/UFRJ and EnergiaH [3]. It allows the direct oxidation of ethanol in the fuel cell. Table 1 shows the estimated market for ethanol solid oxide fuel cell in Brazil, considering the demands above discussed.

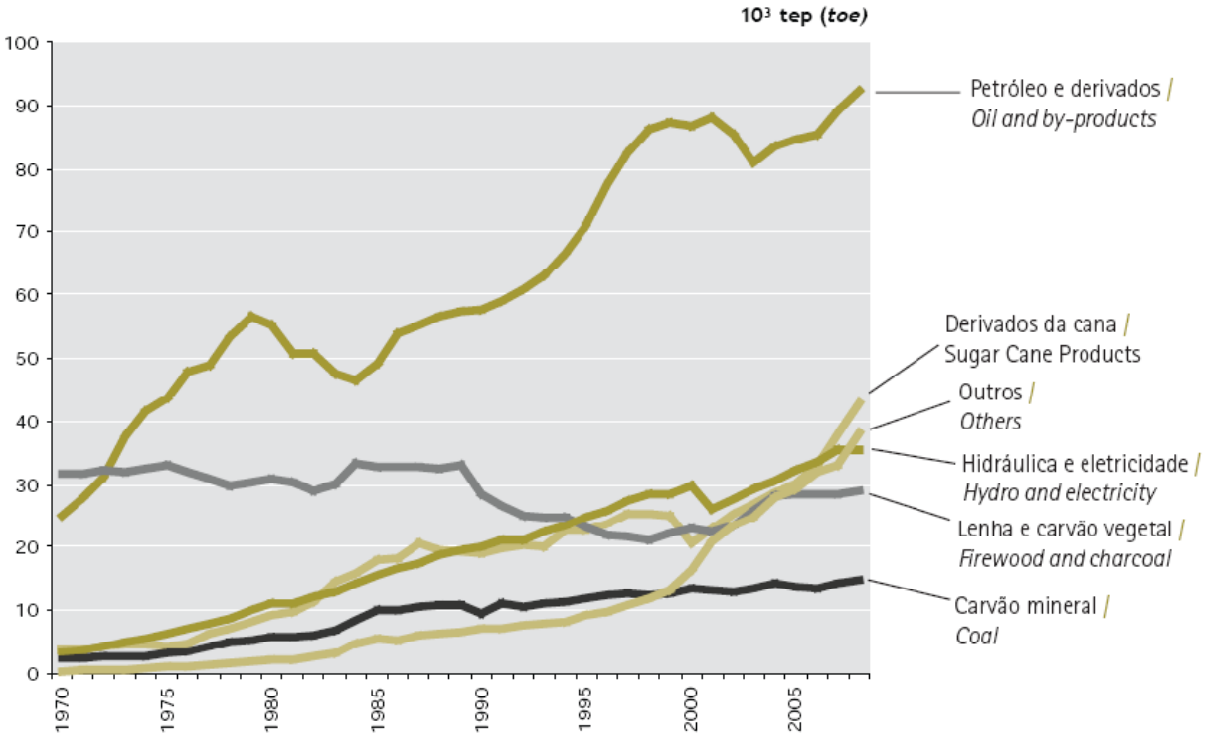

Figure 1: Brazilian Energy Matrix Source: Brazilian Energy Balance [7].

The model developed considers that a percentage of the annual estimated new connection points and additional power needed on existing low power connection points will be supplied with ethanol SOFC´s. 30% is considered to be the highest introduction level for the SOFC market of low power distributed generation in Brazil. The estimated purchase growth rate considers an initial demonstration of prototypes in 2011, to gain market confidence and make additional system developments. The present market has already a potential demand, but it is reasonable to believe that the companies will have a conservative purchasing police. In addition to that, the industrialization infrastructure, the needed technical trained personal and the supplier chain will not be achieved before 2013.

Table 1: Ethanol Solid Oxide Fuel Cell Estimated Market.

annual demand	244.000	**Annual deployment**								
Year		**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	
rate of the annual demand supplied with ethanol SOFC		0,1%	0,5%	2%	3%	9%	20%	25%	30%	Total
Number of 2kW ethanol SOFC´s		244	1.220	4.880	7.320	21.960	48.800	61.000	73.200	218.624

4 Conclusions

The present configuration of the electric energy system in Brazil, associated with the high production of ethanol, the already implanted distribution network for this renewable fuel and the new SOFC anode that allows the direct oxidation of ethanol, present an unique opportunity to develop and industrialize solid oxide fuel cells in Brazil.

For a 2 kW ethanol SOFC and if the electric regulations are kept as they are nowadays, there is a significant market for distributed generation with an attractive price. The biggest challenge in the present scenario is considered to be the technological development of a simpler balance of plant (BoP) and the demonstration of the first fuel cells prototypes.

References

[1] Laufer, A. PhD. Thesis, Coppe/UFRJ, Rio de Janeiro, 2008.

[2] Furmana J. L.; Porter M. E.; Stern S. “The determinants of national innovative capacity”. Research Policy 31, pp. 899–933, 2002.

[3] Miranda, P.E.V.de; Venâncio, S.A.; Miranda, H.V.; “Process for the direct oxidation and/or internal reforming of ethanol, solid oxide fuel cell used for the direct oxidation and/or internal reforming of ethanol, catalyst and multifunctional electrocatalyst anode for the direct oxidation and/or direct internal reforming of ethanol”. INPI process no. PI0901921-9, 17/06/2009.

[4] Brazilian Federal Law. number 11.196, November 21, 2005. Accessed in February 25,2010: http://www.planalto.gov.br/ccivil_03/_Ato2004-2006/2005/LEI/L11196.htm

[5] Sicsú J., Castelar A., “Estratégias de crescimento e Desenvolvimento”. Instituto de Pesquisa Econômica Aplicada – IPEA, Brasília, 252 p., 2009.

[6] Borges, M.R.N.; Carvalho, P.C.M.; “Planejamento Energético Rural Assistido por Computador”. Eng. Agríc., Jaboticabal, V.29, N.2, pp.172-184, abr./jun. 2009.

[7] Brazilian Energy Balance 2009, reference year 2008. Balanço Energético Nacional 2009: Ano base 2008 / Empresa de Pesquisa Energética. – Rio de Janeiro: EPE, 274 p., 2009.