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Financial Investments in Fuel Cells and Hydrogen Projects in Brazil

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Abstract

This work aims to identify, classify and account for the investments in hydrogen and fuel cells from 1999 to 2007 made by the public and private sectors in Brazil. Two methodologies were applied to obtain the data for this study. The Top-Down methodology was used to obtain the information from the sponsoring agencies, institutions and funds that promote science and technology in Brazil, such as *CNPq*, *FINEP*, *P&D ANEEL* and Regional Foundations for Research Support. The Bottom-Up methodology consisted in obtaining data directly from the research groups granted by those agencies. After accounting the total Brazilian investment in the period, this was compared with the investments made by the other BRIC countries (Russia, India and China). Next, BRIC countries investment was compared with those made by the European Union, Japan and the United States. The results show that in order to participate in the market share related to equipment and services for the hydrogen economy, Brazil needs to increase the efforts in research, development and innovation in the area. It will be also necessary to apply resources in other important research issues besides ethanol reforming, polymer electrolyte and solid oxide fuel cells, which are the current technologies supported by the Brazilian funding agencies. To achieve this, resources that are already available could be used more efficiently. Another important evidence is that the total annual investment made BRIC countries together is of the same order of magnitude as the investments made separately by the European Union, Japan and the United States.

Key words: Hydrogen, investments, fuel cell

1 Introduction

Brazil has two national programs for the development of the hydrogen economy; one articulated by the Ministry of Science Technology (MST) and another by the Ministry of Mines and Energy (MME). In 2002, the MST created the Brazilian Program for Fuel Cell Systems (PROCaC) and in 2004 MME created the roadmap for the introduction of the hydrogen economy in Brazil under the IPHE.

Several factors led the Brazilian government to organize actions about the use of hydrogen as an energy vector, namely: the concerns about climate change, the intensive use of fossil fuels, the dependence of imported oil from politically unstable countries, the importance of integrating renewable energy sources into the global energy matrix. Considering the efforts already made in the country under PROCaC, this study aims to evaluate comprehensively the investments in hydrogen and fuel cells in Brazil and compare them with those made by other countries, which can enable better strategic planning for the sector.

1.1 Methodologies: *Bottom-Up and Top-Down*

In this work, the Bottom-Up strategy was employed to obtain information directly from the research groups of universities or other institutions. On the other hand, the Top-Down methodology was employed to obtain information from the funding agencies of R&D projects, such as the National Council for Scientific and Technological Development (CNPq), Research and Projects Financing (FINEP), State Research Foundations (FAPs), National Energy Agency (ANEEL), National Petroleum Agency (ANP), etc. In this work, the consulted FAPs were FAPESP (São Paulo), FAPEMIG (Minas Gerais), FAPERJ (Rio de Janeiro), FAPERGS (Rio Grande do Sul), FAPESB (Bahia), FAPESC (Santa Catarina), and Fundação Araucária (Paraná). The choice of these FAPs was due to the great concentration of R&D groups working on hydrogen and fuel cell technologies in their respective states.

1.2 Total investments in hydrogen and fuel cells in Brazil

Table 1 presents a comparison between the total values obtained by both methodologies in each research field in Brazil from 1999 to 2007. There is a difference in values determined in each methodology, and this will be better explained later in this work. But the percentages in each of the areas were in good agreement.

Table 1: Investments in hydrogen and fuel cell technologies in Brazil from 1999 to 2007 according to the methodologies *Bottom-Up* and *Top-Down.*

	Investments *Bottom-Up*		Investments *Top-Down*	
Area	Million dollars	Percentage	Million dollars	Percentage
Hydrogen	16.9	41%	17.52	40%
Fuel Cell	18.06	44%	20.16	46%
Others Activities	6.17	15%	6.12	14%
TOTAL	41.13	100%	43.81	100%

The figure found in the methodology Top-Down (43.81 million U.S. dollars) was greater than that obtained in the Bottom-Up (41.13 million U.S. dollars). The calculated difference of 2.68 million dollars corresponds to 6%, which can be considered reasonable. But the difference in the number of projects between the methodologies reached 200, which is highly above the expectations. One possible explanation is that 43% of the R&D groups have not responded to the questionnaire; in addition, 54% of the respondents submitted incomplete answers. Another reason to be pointed out was the great difficulty in obtaining information from the funding agencies. The only exception was ANEEL, which has a database on its website containing all information related to R&D projects. In this case, only minor mistakes were found, related to the repetition of some projects in the database. Additionally, FAPESP may have supported a large number of small projects or accounted for scientific initiation scholarships, masters and doctoral projects. But, unfortunately, this could not be verified and revised.

1.3 Investments in hydrogen and fuel cell in the world

The major hydrogen programs in the world are carried out in the United States of America (U.S.), Japan and the European Union (EU). According to UNEP (2006), these countries account for about two thirds of the public investment in R&D of technologies related to hydrogen.

This work corroborates the findings of UNEP (2006), that the largest investors in hydrogen and fuel cells in the world are: the United States, Japan and the European Union. Although there are significant projects and investments in other countries, for instance Canada, Germany and Iceland, they are not presented here. Investments made by Russia, China and India have somewhat similar levels to those made by Brazil.

Table 2: Federal Investments in the Hydrogen Economy by BRIC countries: Brazil, Russia, India and China (amounts in millions U.S. dollars).

Year	Brazil *Top-Down (reference)*	Brazil *Top-Down* and *Bottom-Up*	Russia	India	China
1999	0.59	3.38	*na	na	na
2000	10.51	13.45	na	na	na
2001	1.15	4.09	na	na	24.07
2002	4.99	7.93	na	na	24.07
2003	5.52	8.45	na	na	24.07
2004	3.03	5.97	37.00	na	24.07
2005	5.29	8.23	30.00	18.97	24.07
2006	3.73	6.66	30.00	19.85	9.40
2007	9.00	11.94	30.00	18.89	
TOTAL	43.81	70.10	127.00	57.71	129.75
Annual Invest.	4.87	7.79	31.75	19.24	21.63
Total annual invest.		80.41			
%	***	10%	39%	24%	27%

na =not available

According to the data in Table 2, Brazil was the BRIC country which invested the least, accounting for 10% of the total annual investments made by BRICs.

The original intent was to obtain complete data from 1999 to 2007 in order to compare investments with those obtained in Brazil. However, in Table 2 and Table 3, one can observe

that there are some gaps due to the lack of information. So, it was chosen a similar period to make comparisons. Table 3 shows the period between 2001 and 2007 and includes data for all countries.

Table 3: Federal Investments in the Hydrogen Economy by BRICs, U.S., Japan and EU (millions U.S dollars).

Year	BRIC	U.S.	Japan	EU*
1999	3.38	Na	na	na
2000	13.45	na	79.66	na
2001	28.16	209.70	118.36	119.64
2002	32.00	240.70	165.00	109.45
2003	32.52	294.00	255.73	137.45
2004	67.04	298.50	310.58	159.09
2005	81.27	221.70	340.97	166.73
2006	65.91	232.46	288.18	154.00
2007	60.83	267.56	197.12	165.46
TOTAL	384.56	1.764.62	1.755.60	1.011.82
%	7.82%	35.89%	35.71%	20.58%
% U.S., JP & EU	***	38.94%	38.74%	22.33%

Total: BRIC, U.S., JP & EU	4,916.60
Total: U.S., JP & EU	4.532.04

In fact, Table 3 shows that BRIC investments over the period were modest, accounting for 7.82% of the total investments made by BRICs, U.S., Japan and the European Union. The total amount invested by BRICs is in the same order of magnitude of the annual investments made by the United States, Japan or the European Union, individually.

2 Conclusions and Suggestions

The lack of clear criteria to classify investments by the research institutions can be identified as one of the major problems in the development of this work, as well as the difficulties associated to the questionnaires that were not properly answered.

Despite the efforts, most of the funding agencies did not provide adequate information about the investments in the projects they were supporting. The exception was the R&D program supported by ANEEL that makes all information publicly available on its website.

Most of the Brazilian investments in fuel cells were aimed to PEMFC, with 56%, followed by SOFC with 37%. Regarding hydrogen projects (production, storage and distribution), ethanol reforming accounted for 95% of the amount invested, and the most significant share was allocated to the development of catalysts for reformation.

According to the data available for the period 1999-2007, the annual amount invested by BRIC countries corresponded to 80.41 million dollars, which was in the same order of magnitude of the annual public investment made by the United States, Japan or the European Union individually. However, it is also known that the private sector participation in these countries is substantial while in Brazil, nowadays, this participation can be considered low, at least in the hydrogen-related technologies.

Even without complete data for the period of interest, it was noted that the annual investment made by Brazil was the smallest among the BRIC countries. Despite the important achievements that have been communicated by the Brazilian research groups, this conclusion indicate that to improve its market share of equipment and services related to the Hydrogen Economy, Brazil will need to increase the efforts in research, development and innovation in several areas beyond ethanol reforming, proton exchange and solid oxide fuel cells. This can be achieved by employing new sources of funds and by making better use of the existing financial and personnel resources.

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