BRAZILIAN CENTRE FOR DEVELOPMENT OF PHOTOVOLTAIC SOLAR ENERGY: MISSION, INFRASTRUCTURE AND ACTIVITIES

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ABSTRACT: This paper presents the Brazilian Centre for Development of Photovoltaic Solar Energy – CB-Solar, a National Centre established at May 2004, by a cooperation agreement formed by federal, state and municipal governments and a local electric utility as well as the Pontifical Catholic University of Rio Grande do Sul. The centre has the mission of promoting the development of more efficient structures to convert solar energy to electrical energy, to evaluate the economical viability of solar cell and module fabrication processes, to implement PV systems and to prepare qualified human resources.
Keywords: Photovoltaic centre, PV development, Strategy

1 INTRODUCTION

Brazil is a country with a high amount of solar energy from north to south and with more than twelve million people without access to electricity. Continental distances and small energy demands make the use of photovoltaics in solar home systems or in mini grids very interesting from an economic point-of-view. Since 1970 several solar technologies in Brazil were studied and in the 80´s a PV module fabrication plant started-up. After the "golden decade", with the progressive reduction of investments, many solar energy research groups closed, and only during the 90´s, did PV research recover status in university research. In 1995, the Brazilian government implemented a new program to promote rural electrification with PV systems, the PRODEEM, Program for Energetic Development of States and Municipalities, involving several universities and State Secretariats. This program installed many small systems from 1995 to 2002, with a total of 6 MWp, half of the PV power currently installed in Brazil (12 MWp). Grid connected systems remain as university case studies, with only 44 kWp installed. Although research has been advanced in recent years, there is not a government strategy to promote photovoltaics for applications, research on cost-effective technologies or industrial development.

Bearing this in mind, Solar Energy Technological Nucleus of the PUCRS (Pontifical Catholic University of Rio Grande do Sul), Ministry of Science and Technology (MCT), Secretariat of Energy, Mines and Communication and Secretariat of Science and Technology, both of state of Rio Grande do Sul, the Municipality of Porto Alegre and the State Electrical Utility (CEEE), established in May 31th, 2004, the CB-Solar, Brazilian Centre for Development of Photovoltaic Solar Energy. It is worth mentioning that MCT has signed six scientific cooperation agreements to establish reference centres for development of renewable energy in Brazil: thermal solar energy, small hydroelectric plants, hydrogen, biomass, biofuels and the centre for PV development. Role of centres of excellence for dissemination of PV was already discussed in the past [1], [2].

The purpose of this paper is to present the mission of the CB-Solar, the infrastructure and main activities initiated during the first year in order to promote photovoltaics in Brazil. At the same time, CB-Solar approach will be commented considering the favourable politic and economic moment to develop this technology to mitigate social problems and to diversify Brazilian electrical sector domination by hydro power plants.

2 ORGANIZATION

The activities of the CB-Solar consists of promoting the development of new and more efficient structures for photovoltaic energy conversion, analysis of technologies for economic fabrication of solar cells and PV modules, study and establishment of photovoltaic systems and training of the necessary manpower, thus combining education, research, development and applications.

CB-Solar is coordinated by a director committee and managed by an executive secretariat. Director committee is constituted by one representative of each earlier commented partner and coordinated by PUCRS member. This committee supervises all activities and executive secretariat implements the projects and coordinates the technical personnel and it manages the funding. Figure 1 displays the organizational structure of the centre and the main partners and activities.

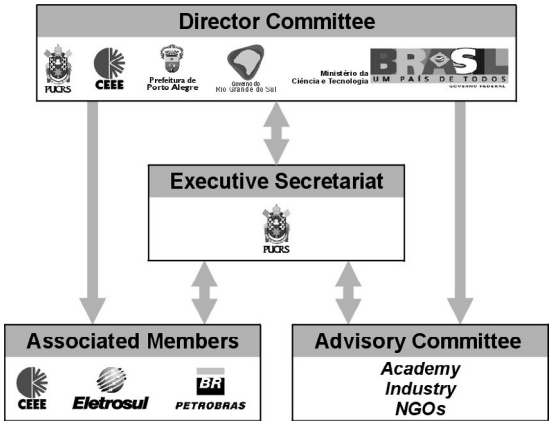


Figure 1: Organizational structure of CB-Solar.

Besides the main partners that formed the

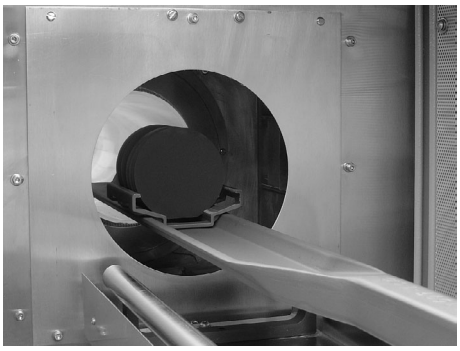
cooperation agreement for implementing the centre, new members can participate as associated members. They may be utilities, industries, oil/gas companies, NGOs, etc, that will support specific projects. A Technical Advisory Committee was established to aid Director Committee in their activities. The Technical Advisory Committee is composed by representatives from academy, industry and non-governmental organizations (NGOs), all involved with PV development or applications.

3 INFRASTRUCTURE

CB-Solar was implemented by using the infrastructure of the Solar Energy Technological Nucleus of PUCRS. This centre is one of the most modern and well-equipped photovoltaic research centres in Latin America having a total area of around 700 m^2 of which 216 m^2 are clean room labs (10.000 class, ISO7).

The clean room is supplied with high quality gases distributed through labs by electropolished stainless steel tubes. High purity water is obtained by reverse osmosis and ion exchange equipments. Water piping is made of PVDF and water is recirculated each hour to avoid the formation of bacteria in the tubes. The clean room was designed to produce Si solar cells (mono and multicrystalline) and modules with different metallization techniques (screen-printing, electroless, e-beam metal evaporation) and different ways to diffuse impurities (conventional and rapid thermal furnaces). Systems are designed to 4" round wafers or pseudo-square 100 mm x 100 mm wafers, but up to 6" round wafers can be used. Figure 3 presents several photos of the laboratories: including furnaces and an outdoor testing facility. In the centre, researchers can design a cell, fabricate batches and produce modules. Furthermore, modules can be tested following national and international standards and it can be monitored on outdoor conditions or integrated in PV systems.

(a)



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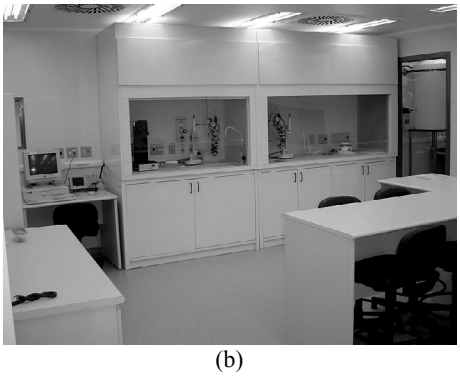

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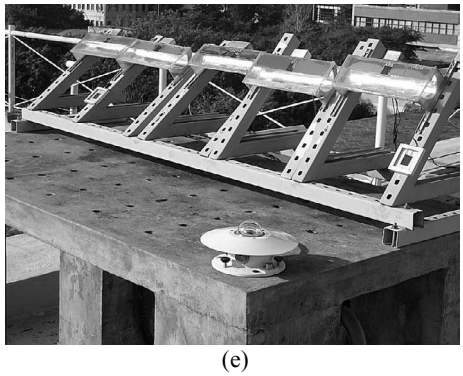

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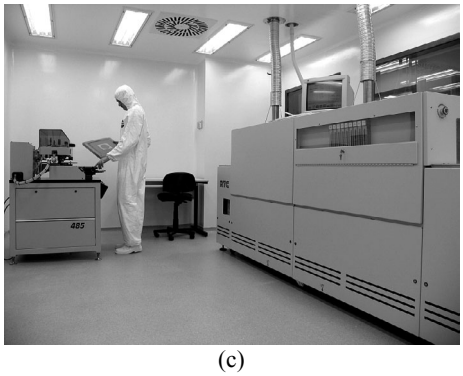

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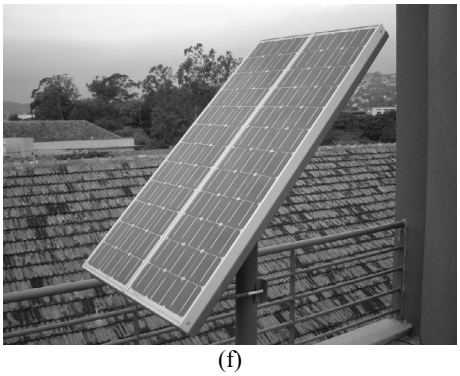

(f)

Figure 2: (a) Physics R&D Centre, where CB-Solar was installed, at PUCRS campus, Porto Alegre, Brazil; (b) chemistry lab; (c) screen-printing lab; (d) diffusion furnace; (e) static concentrator prototypes; (f) stand-alone photovoltaic system.

3 ACTIVITIES

3.1 Research & development

CB-Solar research staff has been working on silicon solar cell processing, development of static concentrators and design of stand-alone systems.

Concerning silicon solar cells, a process to obtain bifacial cells by rapid thermal diffusion and screen-printing is under development. This project is supported by a local electric utility (CEEE) and the Brazilian Agency for Development of Science and Technology (CNPq, Conselho Nacional para Desenvolvimento Científico e Tecnológico). Highly doped regions were optimized by PC-1D simulations and simultaneous diffusion of boron and phosphorus was experimentally optimized taking into account optimum sheet resistance and bulk lifetime (measured with a commercial photoconductivity decay equipment) [3].

Monofacial industrial cells have been also studied. For example, a technology based on phosphorus/ aluminum as dopants and based on gettering was developed for lab cells [4] and it is being transferred to a pilot production. Supported by Ministry of Science and Technology, through the Brazil Technology Network (RBT, Rede Brasil de Tecnologia) and the financing agency (FINEP, Financiadora de Estudos e Projetos) as well as three Brazilian companies (CEEE, Eletrosul and Petrobras), the purpose is to produce PV modules in a pilot line by using the technology developed at PUCRS.

Considering the need of stand-alone systems for rural electrification, static concentrator modules for this kind of systems have been optimized for different regions of Brazil [5], [6]. Several prototypes were built and are under experimental evaluation. Furthermore, static concentrator PV modules have been designed for façades of buildings connected to the grid [7].

Efforts have been made on the design of stand-alone PV systems and an analytic method for sizing these systems was developed and it is now under experimental evaluation at CB-Solar [8], [9]. For example, to check the model, a typical system constituted of two 50 W PV modules, two 120 Ah steady-state batteries, charge controller and lamps have been monitored. Except PV modules, all equipments of this system are from Brazilian industries.

3.2 PV labelling program

CB-Solar staff also is working with the Brazilian Program for Labelling PV Systems. This program aims to establish the standards for labelling PV systems and their components [10]. The task force composed by specialists from universities, Brazilian suppliers, manufacturers and public organizations and coordinated by INMETRO (Brazilian Institute for Metrology, Standardization and Industrial Quality), had been prepared the standards tests for PV modules, batteries, inverters and charge controllers as well as complete PV stand-alone systems.

3.3 Brazilian symposium

One of the first activities of the centre was to organize, jointly with two other university research centres (IEE-USP, Instituto de Eletrotécnica e Energia, Universidade de São Paulo and GEDAE-UFPA, Grupo de Estudos e Desenvolvimento de Alternativas Energéticas, Universidade Federal do Pará) and MCT and Federal Ministry for Mines and Energy, the First Brazilian PV Solar Energy Symposium in order to discuss the past, present and future of this technology in Brazil. Symposium was held in Porto Alegre, 19-21th July, 2004. More than 135 specialists participated, most of them from universities, research centres, utilities, federal and state agencies, metallurgic grade silicon suppliers and industries that produce BOS components for PV systems, and specialists of PV industries as well as non-governmental organizations. During the symposium, several subjects were discussed. Technological aspects like production of solar grade silicon by alternative routes, thin films cells and low cost Si solar cell processing were presented as well as PV-systems design and implementation, mainly for rural electrification, water pumping and purification were discussed. At the same time, utilities presenting R&D programmes and applications and NGOs, that uses photovoltaics to promote development, presented your experiences. Strategies for developing photovoltaic in Brazil were presented. A second Brazilian Symposium on PV was held at Rio de Janeiro, 17-20 May, 2005, this time coordinated by CRESESB (Brazilian Solar and Wind Energy Reference Centre, sponsored by Federal Ministry for Mines and Energy) and more than 200 people attended to the conference. After these first symposia, specialists in PV concluded that Brazil needs a government programme in order to develop PV in Brazil bearing in mind that the country has technology, industry and the need of rural electrification and new energy sources. This programme would include incentives for stand-alone and grid connected systems. It is the only way to rapidly develop PV technology in Brazil and to establish a baseline industrial park.

3.4 PV promotion

PUCRS staff had been very active of promoting PV for high school and college students and teachers. For examples, during the first year operation of CB-Solar, we carried out several guided tours for high-school and college students of other universities.

Another way to introduce PV to students is through topics covered in university admittance exams. For instance, PUCRS introduces in the admittance exam the topics “pn-junction and photovoltaic effect” and now, several high-schools introduce it on your curriculum.

CB-Solar had been participated on several events related to energy and environment, presenting PV advantages and challenges. For example, in an innovation fair (Globaltech) that was held at Porto Alegre last May, we participated in three stands and PV powered toys were exposed to catch attention for PV applications.

4 CONCLUSIONS

A centre for PV development was established in Brazil in order to promote photovoltaic research and applications. Research and development on silicon solar cells, pilot production, PV system design, design and fabrication of static concentrator modules, characterization and certification of the components of a PV system (modules, batteries, charge controller and inverter) are the main activities of the centre. PV promotion is one the most important challenges and CB-Solar, jointly with other Brazilian research centres promoted the first national symposium on PV and it had

been actively participating of events related to renewable energy in Brazil.

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