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Economic overview of the use and production of photovoltaic solar energy in brazil

Agmar Ferreira[a,*], Sheila S. Kunh[a], Kátia C. Fagnani[a], Tiago A. De Souza[b], Camila Tonezer[c], Geocris Rodrigues Dos Santos[d], Carlos H. Coimbra-Araújo[c,e]

[a] Master of Science Programme in Technologies of Agrobusiness Bioproducts (PGT/UFPR) Universidade Federal do Paraná, R. Pioneiro, 2153, 85950-000 Palotina, Brazil
[b] Universidade Federal do Paraná (UFPR), Rio Pioneiro, 2153, 85.950-000 Palotina, Brazil
[c] Department of Engineering and Exact Sciences, Universidade Federal do Paraná, R. Pioneiro, 2153, 85950-000 Palotina, Brazil
[d] Department of Mechanical Engineering, Universidade Tecnológica Federal do Paraná, Via do Conhecimento, km 1, 85503-390 Pato Branco, Brazil
[e] Doctor of Science Programme in Environment and Development (PPGMADE/UFPR), Universidade Federal do Paraná, R. dos Funcionários, 1540, 80035-050 Curitiba, Brazil

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ABSTRACT

The technology of photovoltaic power generation has been increasingly regarded in many countries as an alternative to reduce the environmental impacts associated with climate changes and dependence on fossil fuels. Countries such as Germany and other European countries have been developed specific regulatory mechanisms to encourage its use either by government programs or by financial and/or tax incentives. In Brazil, despite the large existing solar potential, the encouragement to technology is still incipient. This paper aims to demonstrate the key aspects of the evolution of regulatory incentives to use photovoltaic solar energy in Brazil and present the technologies and characteristics of photovoltaic power generation.

1. Introduction

The increase of the demand and consumption of energy resulting from technological progress and from advancement in human development are seen as the most important factors in the acceleration of climate and environmental changes observed and described by the scientific community. Recent studies have shown an upward trend in energy demand as a result of economic recovery in developing countries. The current growth trend suggests that probably in the second decade of this century, energy consumption in developed countries will be exceeded by consumption in developing countries due to the improvement of socio-economic parameters in these countries [1,2].

According to data from the International Energy Agency and Key World Energy Statistics [3], Brazil, Russia, India and China account for 32% of world energy demand. Among them, the highlight is China with 2417 million toe (tons of oil equivalent), which corresponds to 19% of the world energy demand. Russia comes next with 701 million toe (6% of world demand), after India with 692 million toe (5%) and finally Brazil with 265 million toe (2%). About this, see also [4–13].

Although China presents the greatest world's energy demand, its per capita consumption (1.81 toe/person) is below the world average (1.86 toe/person). Similarly, India, even reaching 5% of world demand, has a low per capita consumption (0.59 toe/person). On the other hand, Russia presents a per capita energy consumption (4.95 toe/inhabitant) of developed country. Brazilian consumption (1.36 toe/inhabitant) is in an intermediate position among the BRICs, down slightly from Chinese consumption.

Petroleum is the major commodity in the Brazilian energy matrix, representing about 60% of the total consumption energy sources, used mainly to provide much of the energy demand in the transport sector. It is also important to denote that about 40% of the energy comes from sugarcane bagasse and traditional biomass, as shown in Fig. 1.

Currently hydropower is the main source of energy for electricity generation in Brazil, accounting for 62.44% of production, as shown in Fig. 2.

Hydropower is considered renewable and clean, however its application is restricted due to the environmental impacts caused by the flooding of large areas, by the emission of methane (CH_4) resulting from the anaerobic degradation of organic material submerged by flooding, and due to hydrological dependence of the region to be implemented [16].

* Corresponding author.
E-mail address: agmarferreira79@gmail.com (A. Ferreira).

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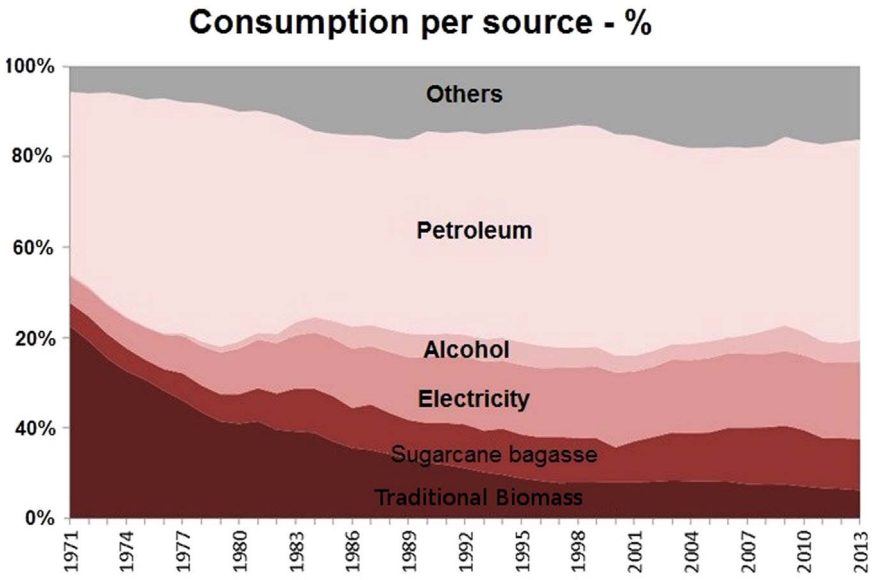

Fig. 1. Brazil's energy matrix versus time. Source: MME, 2014 [14].

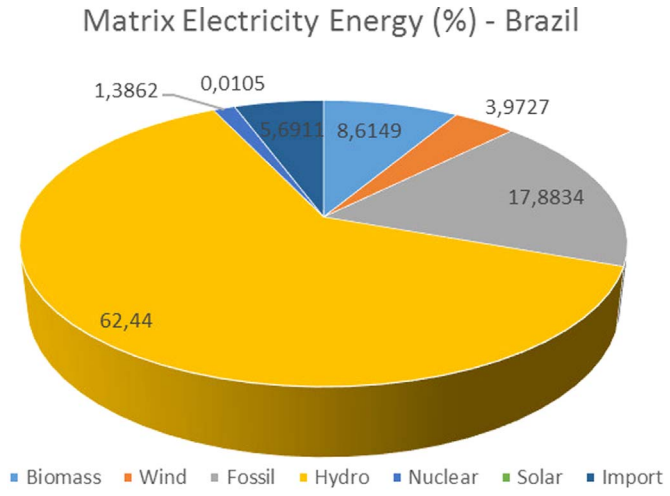

Fig. 2. Brazilian energy matrix. Source: ANEEL, 2014 [15].

On the other hand, Brazil, as a country located mostly in the intertropical region has great potential for solar energy utilization throughout the year. The use of solar energy brings long-term benefits for the country, enabling the development of remote regions where the cost of electrification by conventional network is too high in relation to the financial return on investment, regulating the energy supply during drought periods. There is a wide range of possibilities in the medium and long-term use of this abundant form of renewable energy, ranging from small independent photovoltaic systems to large power plants that use concentrated solar power [17].

According to Rüther [18], the solar photovoltaic systems, especially those integrated with urban buildings and connected to distribution system, offer several advantages to the electrical system, many of which relate to avoiding costs, which are not yet considered or quantified, such as: a) reduction of losses due to transmission and distribution of energy, as electricity is consumed where it is produced; b) Reduction of investment in transmission and distribution lines; c) buildings with integrated photovoltaic technology does not require dedicated physical area; d) solar photovoltaic buildings provide larger volumes of electricity at times of peak demand; e) When strategically distributed, photovoltaic generators offer minimal idle generation capacity for its great modularity short term installation, providing speed on the demands of adding generating capacity.

However, nowadays this energy still has an incipient participation in the Brazilian energy matrix - thermal solar energy for water heating has aroused interest in the domestic market, mostly for the use between classes A and B of society, in the industry and hotel services.

Much of the potential investors and producers in the energy sector do not have information or knowledge, with the necessary scientific background, about the options in renewable energy sources, and because of that, they tend to avoid the economic and financial risks associated with the development of projects in this area [19].

The present article aims to supply part of the demand for information about the solar energy availability in Brazil, government incentives and overview of the current legislation. Specifically for the case of the present review, it has been possible to observe that the generation of photovoltaic energy is an alternative to the diversification of the Brazilian energy matrix. It will be seen that although the country come trying over the years to encourage the photovoltaic source, as a renewable source, this incentive is still very modest to increase its share in the national energy matrix. The projects installed through government actions use autonomous systems and focus on isolated houses, far from the distribution networks. To comprehend such picture, firstly the paper will review in Section 2 technologies and applications of photovoltaic systems, and it will be addressed in Section 3 the main information about costs and learning curve and in Section 4 the potential use. In Section 5 it will be discussed some historical aspects of the development of solar energy in Brazil, mainly in what concerns to photovoltaic systems and the current situation of National fomentation programs. Section 7 will discuss the main actual government incentives and the Brazilian regulatory panorama, and in Section 8 it will be made some final considerations.

2. Technologies and applications of photovoltaic systems

All photovoltaic systems can be characterized into five groups:

i) Connected to the network: the photovoltaic system connected to the network, usually installed on house roofs and buildings, consists of a photovoltaic panel that converts the sun energy into electricity (direct current) in which the presence of an inverter is required, which converts direct current into alternating current with tension and frequency compatible with the electric grid standards to which the system is connected. The main advantages of this type of system are high productivity, the absence of battery