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Review of distributed generation with photovoltaic grid connected systems in Brazil: Challenges and prospects

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ABSTRACT

Brazil has a clean energy matrix, mainly due to its intensive use of hydropower for electricity generation and sugarcane ethanol for transportation. Nevertheless, following a worldwide trend, the penetration of non-conventional renewable and alternative energy sources into the grid such as wind and small hydro, has increased. This greater participation of alternative renewable sources in the electricity market has occurred due to specific market mechanisms designed to stimulate its implementation, but solar energy utilization is highly untapped and underutilized. This study will give a background on the development of the first photovoltaic systems and show the importance of solar energy for the diversification of the electric energy matrix in Brazil. The incentives implemented to date will be described, along with others that, if put into practice, could further the development of solar electricity generation. The main obstacles to the widespread utilization of solar generation and some policy recommendations are also described.

1. Introduction

The development of grid connected photovoltaic systems (PVS) in Brazil has been steady but slow in the past years, despite the need for the diversification of the electric generation matrix and the good solar radiation in the country, mainly in the northeast region. The aim of this work is to describe how the development of PVS has occurred and point out the challenges to its widespread utilization. The main barriers may be classified as technological, legislative (policy) and financial. Some relevant statistics about PVS development will be presented to back up the conclusions and recommendations for a more significant penetration of this important renewable source of electricity. The incentives applied in Brazil to foster the development of PVS will be presented, along with other incentives that could be used to impel the usage of solar generation. This topic will be developed thoroughly due to its importance, since most forms of established electricity generation once needed special incentives to develop, mature and compete fairly with other forms of generation.

The installed generation capacity of the Brazilian power system is approximately 138 GW, from which about 63% is hydroelectric. This figure shows that the electric energy matrix is, for its most part, renewable, but also that the country depends on the stochastic availability of water to generate the bulk of its electricity. Solar energy utilization is highly untapped and underutilized. Solar photovoltaic electricity generation has an installed capacity of 15,236 kW and is mainly used to supply isolated and remote energy systems. Despite the essentially renewable electric energy matrix, the penetration of non-conventional renewable and alternative energy sources into the grid (in this work, these will all be termed “renewable energy sources” or RES) has increased in the system.

The electric and energetic matrices in Brazil are not similar. Fig. 1 shows the characteristic of these matrices for the year 2014 [1]. With respect to the electric energy matrix, adding electricity imports, which also come essentially from renewable sources, it can be stated that nearly 68% of electricity supply in Brazil originates from renewable sources, even without taking into account that part of the thermal generation that comes from biomass, which would raise the share to 76.6%.

Solar power is earth's most abundant natural resource. The solar power shining on 135 square miles is greater than the peak capacity of all the electric power plants on earth [2]. Among all the RES present in the Brazilian power system, solar photovoltaic (PV) is the one with the smallest installed capacity, barely showing up in the statistics.

This fact seems odd for a tropical country. From a strategic perspective, Brazil has a number of favorable natural features such as high levels of insolation and large reserves of quality quartz, which can generate important competitive advantage for the production of silicon with high purity, solar cells and modules, which are products with high added value [3]. These factors could pave the way for a more important role of the PV technology in the diversification of the electric energy

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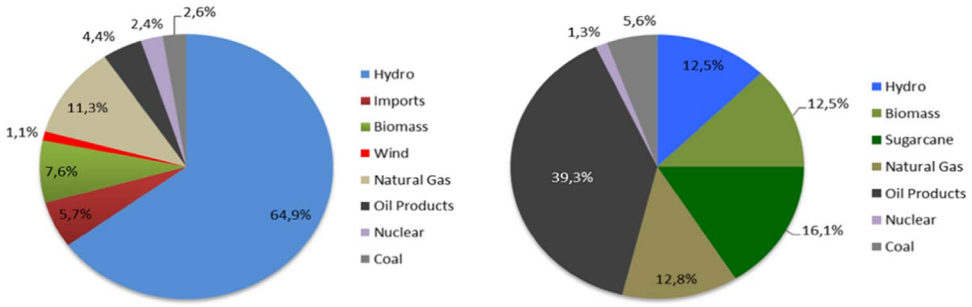

Fig. 1. Electric and energetic matrices in Brazil.

matrix. This work distinguishes two forms of PV generation:

- Distributed generation – PV generators connected directly to the distribution network, mainly used to supply residential and commercial customers and export eventual power surpluses back to the grid.
- Centralized generation – PV generators programmed and dispatched by the independent system operator (ONS).

The increase in the participation of RES based generation has been possible through the use of regulatory incentives granted by the government to these generators. Until recently, PV connected to distribution networks lacked an adequate regulatory framework. In fact, the energy contracting model for distribution utilities establishes that the purchase of electricity from distributed generation projects (PV included) should be preceded by public notice promoted directly by the distribution agent. The model limits this type of procurement at 10% of the total load of the distribution agent and authorizes transfer to the consumer tariffs up to the limit of a reference value. The problem is that the reference value is always lower than the energy production cost of PV.

2. Solar energy utilization

Renewable electricity generation is increasing worldwide as part of long term strategies aimed at reducing greenhouse-gas emissions and obtaining a sustainable electricity supply [4–7]. It is well known that electric energy generation, mainly the one based on fossil fuels, can cause harm to the environment through the emission of toxic gases and particles.

The Brazilian electric energy matrix is predominantly hydroelectric and, therefore, renewable. The problem is that the power system operation is very sensitive to droughts that can severely lower water storage levels of reservoirs and lead to a rationing period. This problem happened in 2001 and in 2015. The beginning of a severe economic crisis in 2014 led to a reduction in electricity demand by consumers in the country that avoided a shortage of supply in 2015. One way of producing electric energy in a sustainable way is by creating support incentives to alternative and renewable generation. If we consider as alternative energy those generation enterprises that use foreign technology and display generation marginal costs higher than other generation sources (renewable or not), we can include in this category solar photovoltaic plants (PV) and wind farms, besides other methods not present in the national scenario such as geothermal and tidal. In Brazil, these alternative sources of electric energy represent 4.02% of the electric energy matrix, corresponding to a generation of 5.78 GW as of April 2015.

Brazil is stimulating and supporting investment in alternative and renewable generation. In some cases though, this support can have negative impacts on the market. The use of technologies not totally controlled by domestic companies can promote an increase in market prices of energy due to the high costs of constructing and operating these enterprises. The lack of technology produced on Brazilian soil remains one of the main barriers to the development of solar energy. The production of photovoltaic panels and other equipment in Brazil would be a great leap for the cheapening of this source.

The trend is that alternative and renewable energy sources will overcome non-renewable ones. A number of factors are setting the pace of this tendency within the Brazilian electric energy industry. We can mention as factors that contribute to the employment of RES:

- Fiscal incentives and tax credits;
- Development and domination of technologies involved in RES generation to enable the construction and maintenance of projects;
- Natural favorable conditions;
- Social and environmental favorable characteristics;
- Renewables enable electricity generation in a non-centralized fashion and close to the loads. This proximity to the load reduces transmission and distribution system losses.
- Shorter implementation periods.

The generation plan proposed for the upcoming years follows criteria of security for supply and minimization of the expected expansion costs in an environmentally sustainable manner. Such costs are made up of investments (including socio-environmental) in new plants and transmission lines, as well as the costs of operation.

The generation of electricity by harnessing water resources is the electric energy source that will receive the most investment in upcoming years [8]. This fact shows that the planning agents are not confident on the expansion of solar generation due to lack of incentives and financial and technical barriers. One of the obstacles to PVS deployment is the fear distribution utilities have about losing income. The majority of utilities is private and aim for profit in a competitive market. A great number of consumers generating their own electricity will certainly have effects (financial and technical) on the distribution segment, besides the fact that the use of batteries, enabled by smart distribution grids, can create grid independent consumers. The incidence of taxes on generated electricity at state level is another point that needs to be addressed. States should exempt users from this collection to incentivize PV generation and not use it as a way to increase budget. São Paulo is an example of a state that eliminated the collection but others still charge the consumed and generated electricity by utility customers. Another point is that distribution utilities are not prepared to receive big amounts of generation or reverse power flows in circuits, without having to make reinforcements or invest in control and protection technologies. This is why residential consumers cannot inject more power into the grid than their installed demand according to the actual regulation.

It is predicted that by 2023 non hydro sources of generation will account for 16.2% of all the energy supplied to the interconnected power system (SIN), corresponding to 31,748 MW. Solar generation is expected to reach 3,500 MW of installed capacity by the year 2023. Fig. 2 illustrates the projected installed capacity by generation source in the year 2023 [8].