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Outcomes from the first large-scale solar PV auction in Brazil

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ABSTRACT

Auctions have been used to promote renewables and introduce new technologies, and Brazil has a tradition in this field. The Brazilian government designed a framework with the goal of introducing solar PV into the power mix that includes contracts to reduce the risks for investors. The first large-scale auction for this technology was held in October 2014, and the process achieved an average price reduction of 17.26% below the starting price. The auction process was also successful with respect to new contracted capacity, with 31 new power plants and 889.7 MW (AC) of new capacity. Observed capacity factors of winning bids were high, but they were in accordance with new technologies and recent studies. Nonetheless, the regulatory agency must monitor generation performance. Higher investments are likely related to the deployment of tracking technology, reflecting a higher capacity factor. Furthermore, the Brazilian case is unique due to long-term experience and large scale in using auctions for renewables, such as wind and biomass. Lastly, Brazil's example is relevant in international debate given that the country replaced its Feed-in-Tariff program for auctions in 2005, a point that is worth studying in its own right.

1. Introduction

Brazil has a strong tradition of fostering renewables using reverse auctions [1], but solar photovoltaic (PV) has taken more time than expected to be considered as a real option for power generation. Initial moves toward the introduction of solar PV into the power mix were made at the 6th Reserve Energy Auction held on October 31, 2014, where one of the products of the auctions was exclusive for this technology. In this paper, we discuss the outcomes from Brazil's first large-scale auction to contract solar PV.

Environmentalists often argue that solar PV is a convenient solution for meeting the increasing demand for power and thus, they defend solar PV as a sustainable technology, given that it is used both in utility-scale generating plants and in distributed end-use residential and commercial applications. On the other hand, critics argue that small-scale solar PV remains expensive, particularly in comparison with the abundance of hydro energy and renewables available in Brazil. However, it is possible to observe the increase in small-scale solar PV in many different markets, such as the U.S., Germany, Italy and Australia.

The Ministry of Mines and Energy (MME) and the National Electricity Agency (ANEEL) have attempted to develop solar PV as a power-generating technology. The MME first selected solar PV as an eligible competitor source at the 17th New Energy Auction, organized in 2013 [2], but at this auction, solar PV competed head-to-head with other technologies (wind, biomass and natural gas). Thus, as no single solar PV plant won the auction, power plants from other renewables and fossil fuel technologies, with much lower prices, supplied the demand to distributors. ANEEL then attempted to wholly develop solar energy, publishing the Normative Resolution 482 on April 17, 2012 [3]. This resolution regulated micro generation and distributed generation for low-end consumers, allowing them to use the net metering concept for renewables, including solar PV. Unfortunately, Brazilian State Tax Authorities (BSTA) applied a Value Added Tax (VAT) over the production of solar power to be paid by the end consumers until March 2015, disregarding the consumption and the net metering concept, which hindered the small-scale development of solar PV. However, in April 2015, the Brazilian State Tax Authorities Council published a new agreement exempting the end consumer from being charged VAT from solar PV power production. Currently, an analysis of the Brazilian power mix shows that solar PV remains at a low rate. However, the Energy Research Office [4] forecasts that this technology will increase its share in the power mix at a consistent pace, representing 2.3% of the total capacity by 2024.

The MME and ANEEL are attempting to repeat the same path for solar PV as that which was implemented for wind technology, which

Abbreviations[1]: ANEEL, National Electricity Agency (Agência Nacional de Energia Elétrica); BNDES, Brazilian National Bank of Development (Banco Nacional de Desenvolvimento Econômico e Social); BSTA, Brazilian State Tax Authorities; CCEE, Brazilian Wholesale Market Operator (Câmara de Comercialização de Energia Elétrica); EPE, Energy Research Office (Empresa de Pesquisa Energética); FCE, Free Contracting Environment; FEC, Firm Energy Certificates; LCOE, Levelized Cost of Energy; LCR, Local Content Requirement; MME, Ministry of Mines and Energy (Ministério de Minas e Energia); NIS, National Interconnect System; PPA, Power Purchase Agreement; PV, Photovoltaic; RCE, Regulated Contracting Environment; RES-E, Renewable Energy Source for Electricity; VAT, Value Added Tax

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[1] For Brazilian entities the full names in Portuguese are indicated between parentheses

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was initially promoted under the unsuccessful Feed-in-Tariff program called PROINFA. Wind technology gained momentum, however, when it was introduced at Reserve Energy Auctions with exclusive products or specific technology auctions, and in both cases, with a specific contract and regulatory framework [5]. Thereafter, the government signaled at least one auction every year, BSTAs provided tax waivers and regional development banks, as well as the Brazilian National Bank of Development (BNDES), conceded highly attractive long-term loans. Though solar PV did not participate in any FiT program, the auction mechanism and the regulatory framework designed to promote wind technology were reproduced as a way to promote solar PV.

This study investigates the outcomes of the 6th Reserve Energy Auction and the main aspects related to the regulatory framework, including lessons that can be learned by other countries who aim to scale up renewables, especially solar PV. First, the method used here to analyze this auction is presented. Second, a regulatory discussion is introduced, including how the Reserve Energy Mechanism works and the role of the Brazilian Wholesale Market Operator (Câmara de Comercialização de Energia Elétrica, CCEE in Portuguese acronyms) regarding collecting surcharges and providing contract settlements. This paper also explains the auction mechanism and its design, which fosters competition among the generators. In addition, the regulatory framework is presented and discussed, which plays an important role in the success of the solar PV auction as it mitigates risks and assures investors of a business-friendly environment. Then, the auctions outcomes are analyzed, such as contracted power, prices, unit investment costs and the capacity factor of power plants. Lastly, the main conclusions and policy implications of the first solar PV auction are highlighted.

This paper is organized as follows: Section 2 describes the methods used in this paper, while Section 3 discusses the regulatory environment for promoting solar PV, which includes the Reserve Energy Mechanism, auction design, main rules and contract rules. The auction's results and a discussion of winning bids are presented in Section 4, and Section 5 draws conclusions formed from the paper.

2. Methods

We used publicly available results of the 6th Reserve Energy Auction from CCEE [6] and the technical analysis of EPE (Empresa de Pesquisa Energética, EPE in Portuguese acronyms) [7]. It is important to note that this auction had three different products, one for each technology, namely, wind, small hydro and solar PV. Of these technologies, which were auctioned in different products, 31 wind projects with 20-year contracts were awarded, while there were no proposals from small hydro investors. The average price for wind was US$ 58.23/MW h, and a total of 769.1 MW of new capacity (333.4 aMW FEC[2]) is slated to be added to the National Interconnect System (NIS[3]) (for more details, see www.ccee.org.br).

To understand the promotion of solar PV technology in the Brazilian context, we summarized the regulatory framework designed by policy makers. The Brazilian government, attempting to repeat the same path applied in the introduction of wind technology, has developed a set of regulatory measures with the goal of providing a business-friendly environment that fosters competition and promotes the introduction of solar PV technology.

The auction's winning bids and the main available features of solar PV power plants, including power capacity, FECs, capacity factors, investments, locations and prices, were investigated. This investigation provided insight into the future performance of power plants and indicated the type of policy implications to examine.

Registered and qualified bidders were grouped by the Brazilian States (Table 2). Prices and contracted amounts were analyzed with respect to starting price, average price, median price and other basic statistics (Table 3). A comparison of this auction's results with other international solar PV contracting processes is provided (Table 4). Capacity factors versus energy price of winning power plants (Fig. 1), capacity factor and unit investment cost (Fig. 2) were scattered to verify their relation and resulting importance in designing policies to promote solar PV technology.

3. Regulatory discussion for promoting solar PV

3.1. Reserve energy mechanism and Brazilian auctions

Brazil introduced auctions as the main tool for power procurement after two previous distinctive phases, namely the Full Regulation Model (1960–1995) and the Free Market Model (1996–2003). The former was characterized by a fully regulated market in which commercialization was based on agreements among state companies at different levels (federal, state and city utilities). In addition to increasing generation capacity, the state acted as the planner and primary investor. The latter was a free market with companies (state and private) commercializing direct bilateral contracts with free price agreements. At that time, the state assumed the role of regulator, while almost entirely ceding the roles of planner and investor.

The Free Market Model was severely criticized during the supply crisis of 2001 and 2002, a situation that demonstrated the need to reanalyze how to attract new investment in power generation. Mendonça and Dahl [9] noted that the first reform was unsuccessful in attracting new investment due to several failures, such as prices under the minimum break-even point for most of the new projects, Brazil's high cost of capital and the lack of an organized marketplace for the trading of medium- and long-term contracts. Therefore, the Brazilian government led discussions to identify and promote necessary adjustments that would attract investments, including the creation of a marketplace. Policy makers decided to promote a new institutional and regulatory framework that divided the contracting process into two environments: the Free Contracting Environment (FCE) and the Regulated Contracting Environment (RCE). The FCE, which includes all independent producer-generators, self-producers, traders and free consumers, creates free trading operations without a centrally organized auction. In other words, in the FCE, independent producers and traders sell directly to free consumers. In contrast, the RCE is organized around centralized auctions led by the government to supply distributors who meet the lowest bid price criteria.

Currently, the state plays a mixed role, as it organizes the auctions and regulates the power sector while also working as an investor with Eletrobrás[4] companies in new power plant projects, particularly related to large hydro power plants.

However, independent of the contracting environment and the role of the state, Brazil adopted a market design that obliges all consumers, regulated and free, to be 100% contracted. Law 10.848/2004 and

[2] A Firm Energy Certificate is issued by MME. Its calculation methodology for solar PV is the average availability of solar radiation and its forecasted output. In practice, FECs reflect the sustainable energy production in average MW for each generator when interconnected to the grid. For instance, if a generator sells a contract of 10 average MW in the Reserve Auction, it must generate 87,600 MW h a year (10 × 8760 h). In other words, FECs are the maximum quantity of energy that can be sold through contracts (see Azuela and Barroso [8]).

[3] The National Interconnect System is the group of generators and transmission companies of Brazilian power systems under the management and real time grid operation of National Grid Operator (ONS). It represents 98.3% of Brazilian power systems and is formed by multiple private and state-companies in the southern, southeastern-midwestern, northeastern and part of the northern regions. Only 1.7% is related to small isolated areas in the Amazon region.

[4] Eletrobrás is Federal State-owned company responsible for about 30% of total Installed Capacity of the Brazilian market. It also plays a pivotal role with high voltage transmission lines and works as a social entity in poor northern states where it controls distributors' companies with subsidized tariffs.