Evolution of Solar Photovoltaic Support Policies in Brazil and Portugal: a review[i]

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Abstract *Increasing the share of renewables in electricity consumption is centrepiece for energy and climate policies. This motivation has resulted in different approaches across industrialised and developing economies for supporting the diffusion of renewable energy technologies. Through this research, we develop a comparative analysis between Brazil and Portugal, focusing on support schemes for solar photovoltaic electricity generation, for which both countries present significant potential. The analysis yields a detailed mapping of support policies trajectories, by presenting its main characteristics, incentive models, and resulting outcomes. The obtained results are policy-relevant, allowing for a more detailed understanding on the possibilities for support schemes design, adaptation, and the possible outcomes to be obtained from different schemes implementation.*

[i] This paper is part of an R&D program developed by GESEL, in partnership with Energisa, which aims to analyze the impact of distributed generation on economic-financial balance of distribution companies, identifying and proposing regulatory changes able to mitigate these impacts.

1. INTRODUCTION

The development of solar photovoltaic distributed generation is an energy policy goal that has been widely discussed in developed countries, and that has also been gaining attention in developing economies. In this sense, this article aims to compare the photovoltaic support policies adopted in Brazil and Portugal, with the purpose of analysing the regulatory paths and presenting the impact of the measures adopted in both cases. While Portugal implemented its first micro generation support policy in 2007, through a feed-in scheme, the first Brazilian support policy, which relies on a net metering scheme, was introduced in 2012. The different contexts, approaches and policy development stages offer a great basis to the analysis of photovoltaic support measures, which are going to be further discussed in the following sections.

2. THE BRAZILIAN CASE

Brazil has significant solar photovoltaic potential, estimated at 230% of the residential consumption verified in 2013 [1]. This potential, however, had not been widely exploited, given a generation mix strongly reliant on hydro power, which represents 62% of the total installed capacity, corresponding to a capacity of approximately 83 GW. When considering the share of all renewable sources, this number jumps to 78% [2]. This participation on the generation mix, however, already represents a downgrade in comparison to the mix of 2011, for example, when hydropower corresponded to 67% of the matrix. The share of all renewables, on the other hand, was almost the same (79%), what is justified by a lower participation of alternative sources other than hydroelectricity [3].

Since 2012, otherwise, with the hydro crisis and the intense dry period the country was experiencing, which lead to the massive dispatch of Brazilian thermal plants, other sources, complementary to hydro generation, came into light, with the following goals: guaranteeing the reliability of the supply, through the diversification of the electricity matrix, and meeting certain environmental commitments Brazil signed in the COP21. In this sense, the main drivers of the photovoltaic distributed generation diffusion can be identified as: transition to a hydrothermal paradigm, so as the baseload dispatch of high costs thermal plants caused a great increase in electricity tariffs; the need of significant investments in transmission lines, considering that the remaining hydro potential is placed far away from the load centres; the goal of guaranteeing the universal access to electricity; high levels of non-technical losses, which also pushed up the tariffs increase [4]. In this context, the adoption of a photovoltaic distributed generation supporting scheme proved to be increasingly important.

Brazilian photovoltaics supporting policy was introduced in 2012, through the Normative Resolution no. 482, from ANEEL (the electric sector regulatory agency), and consists of a net-metering scheme. The resolution regulated the access of micro and mini generation units to the distribution grid, defining micro generation as system with the maximum capacity of 100 kW, and mini generation, on the other hand, as systems with a capacity cap of 1 MW. It was also established that the electricity produced in these systems could be used for self-consumption or injected into the distribution grid, resulting in energy credits that could be compensated afterwards, over a period of 36 months. The electricity injected into the grid was not allowed to be sold, but lent to the local distribution company, to simplify the energy exchange process. It is important to highlight that the commercialization of electricity surplus was forbidden. In this sense, the following business models were allowed: electricity consumption in the same place where it was produced; and the transferring of the generation to another site registered in the same private individual's registry number (CPF[ii]) or legal entity's national registry (CNPJ), which was called remote self-consumption [5].

From the publication of the 482 Resolution, in 2012, to September, 2015, 1,144 photovoltaic systems were installed around the country, corresponding to a capacity of approximately 11 MW. Despite this increase, the amount of distributed photovoltaic generation in 2015 was only 22 GWh, a contribution of 0,004% to the country electricity consumption [6].

Given the slight response to the net-metering system implemented in 2012, on November, 2015, the 482 Resolution was amended, through the Normative Resolution no. 687. The main changes in the legislation were: redefinition of system's capacity caps, so micro generation maximum capacity dropped to 75 kW, and mini generation cap increased to 5 MW; extension of energy credits compensation period to 60 months; and the creation of two incentive models. One of these allows for the installation of photovoltaic systems in condominiums, so the generation is divided among the condominium members. The second one provides the possibility of creating a cooperative or a consortium in order to install a photovoltaic system and sharing the electricity generation among the members' electricity bills, proportionally to their participation in the venture. It is also important to note that through the 687 Resolution the bureaucratic process necessary to the connection of the system to the distribution grid was also simplified. Finally, the trade of overproduction remained forbidden [7].

One of the effects of this regulatory change was the diffusion process acceleration. From October, 2015 to October, 2016, 4,696 distributed generation systems were connected to the grid, what represents an increase of 381%, against an increase of 261% during the same period of the previous year (from October, 2014 to October, 2015). So the number of micro and mini generation systems actually connected to the grid totals 6,017, of which 5,929 are photovoltaic, corresponding to a capacity of 42,9 MW [8].

The increase in the number of photovoltaic systems connected to the distribution grid, however, reflects not only the changes in the net metering regulation, but also programmes implemented on a state level that include credits to private persons, tax exemption, and other benefits to incentivise the photovoltaic market.

[ii] This would be the equivalent of the American social security number.

3. THE PORTUGUESE CASE

Portugal's climate and energy policy is focused on reducing carbon emissions, increasing energy efficiency, and promoting renewable energies. This is in line with the European Union policy framework in place for delivering competitive, sustainable and secure energy for European citizens [9]. These policies have contributed to a structural shift in the electricity generation mix in Portugal, with decreasing shares of fossil fuel thermal generation and increasing shares of renewables. In terms of evolution, the Portuguese electricity share from renewables was 32.3% in 2007 and increased to 52.1% in 2014, in this period solar photovoltaic grew from a 0.05% contribution to 1.19% [10], [11]. This positive evolution in the Portuguese photovoltaic market is related to its potential for solar electricity generation, among the highest in the EU [12], and with the support mechanisms implemented throughout the past decade to accelerate diffusion. Over the past ten years, a set of support policies for photovoltaics have been implemented and adopted, whose evolution is now described.

A micro generation scheme was implemented in 2007 through the Decree Law no. 363/2007 [13], through which electricity generated should be mainly for local consumption, however surpluses could be injected in the distribution grid. In this scheme, two different incentive models were available. The General Case model, for photovoltaic installations with up to 5.75 kW capacity, through which the electricity surpluses injected in the grid are paid at the same price as the electricity consumed from the grid based on the prices of the electricity supplier of last resort. And the Bonus Case model, for photovoltaic installations with up to 3.68 kW capacity, which must include solar thermal collectors, through which the electricity surpluses were paid a feed-in-Tariff of 0.65 €/kWh, for the first 10MW in capacity installed, with 5% reductions for each additional 10MW in capacity installed. This feed-in-tariff applied during 5 years from installation, after which the tariff is adjusted to the adequate value at the time for an additional 10 years. After the 15-year period the micro generation installations move to the General Case model.

In addition and to further incentivise the diffusion of micro generation units, the Portuguese Government created a tax exemption for the first 5 000 € resulting from electricity generation [14].

In 2010, the Bonus Case model was adjusted by the Decree Law no. 118-A/2010 [15], through this change the micro generation considered could have a capacity of up to 3.68 kW for individual installations, and of 11.04 kW for condominium installations. In this revised model, generators are paid a feed-in-tariff of 0.40 €/kWh during the first 8 years, and 0.24 €/kWh during the following 7 years of the installation. These tariffs are reduced in 0.02 €/kWh on a yearly basis. After the 15-year period the micro-generation installation moves to the General Case model as in the previous case.

In 2013, the General Case model was adjusted by the Decree Law no. 25/2013 [16], through which the micro generations can be remunerated: (1) by a new formula that takes into account the consumer price index; (2) through organised electricity market; or (3) through bilateral contracts.

A mini generation scheme was implemented in 2011 by the Decree Law no. 34/2011 [17], aiming at further incentivising the diffusion of distributed generation units, which were limited thus far. This scheme covered the photovoltaic generation units with a capacity above the limits established for micro generation and up to 250 kW. Two incentive models were available for mini generation. A General Case model, through which no guaranteed remuneration is set, with electricity surpluses remunerated per market conditions. And a Bonus Case model, in which installation up to 20 kW in capacity are paid a feed-in-tariff of 0.25 €/kWh, and where installations with greater capacity, above 20kW and up to 250kW the allocation of feed-in-tariff results from a bidding process in which the most competitive bids are selected. The allocated feed-in-tariff in both cases lasts for a 15-year period, after which the mini generation unit shifts to the General Case model. The Bonus Case model had an overall capacity limit of 50MW.

In 2013, the General Case model was adjusted by the Decree Law no. 25/2013 [16], through which a new formula was adopted, based on which mini generation was remunerated taking into account market prices for electricity and electricity system costs.

The adjustments presented for both the micro generation and the mini generation schemes implemented in 2013 represented the pre-stage of an overhauling change in the Portuguese incentives applied to photovoltaic generation. In terms of support scheme market diffusion outcomes, the micro generation installations evolved from 9 984 installations in 2009 to 23 029 in 2013. The case for mini generation evolved from 310 installations in 2010 to 986 in 2013 [18]. In terms of installed capacity micro generation evolved from 10.7 MW in 2008 to 94.2 MW in 2014. The case for mini generation evolved from 21 MW in 2011 to 64.5 MW in 2014 [19].

This new incentive scheme was implemented in 2014 through Decree Law no. 153/2014 [20], which repealed the micro generation and mini generation regimes in place by introducing two new regimes for distributed generation: the Self-consumption regime and the Small-scale production regime. These regimes include specific incentive models. Self-consumption installations should aim at supplying local demand however with a possibility for injecting surpluses to the distribution grid, in this case the remuneration of injected electricity derives from market prices for the Iberian Electricity Market (OMIE). For this regime, systems with a capacity greater than 1.5 kW are responsible for paying a fixed fee during the first 10 years of production to cover policy and general economic interest related costs.

The Small-scale generation regime covers three categories of installations: electricity generation only, with a feed-in-tariff of 0.095 €/kWh; installations that include an electric vehicle charging point, adding 0.01 €/kWh to the feed-in-tariff; and installations that include solar thermal collectors, adding 0.005 €/kWh to the feed-in-tariff. Considering this the remuneration possibility range from 0.095 €/kWh to 0.11€/kWh. This regime is limited to an annual capacity of 20 MW. This regime is available through a bidding process in which the most competitive offers are selected based on the reference feed-in-tariffs presented. The feed-in-tariff is awarded for 15 years, after which small-scale producers transition to the Special Electricity Production Regime, applied to renewable energy generators in Portugal.

In terms of market diffusion outcome this policy scheme has contributed to 21.4 MW of capacity installed under the Self-consumption regime in 2015, and for 8.8 MW of capacity installed under the Small-Scale generation regime in 2015. Overall, the installed photovoltaic capacity in the Portuguese market evolved from 10.7 MW in 2008 to 189.8 MW in 2015 [19].

4. COMPARATIVE ANALYSIS

Through the presented trajectories for Brazil and Portugal the following table presents the main aspects of the support schemes and their evolution over time.

Table 1. Synthesis of support schemes.

	Brazil	
Year	**Support Policy**	Net Metering Scheme
	Development	**Outcome**
2012	Net Metering scheme for micro generation (≤100kW) and mini generation (≤1MW). Participants accumulate energy credits for excess generation.	1233 installations by 2015. 11 MW of installed capacity.
2015	Net Metering system capacity amended for micro generation (≤75kW) and mini generation (≤5MW)	5529 installations by 2016. 42.9 MW of installed capacity.
	Portugal	
Year	**Support Policy**	Micro Generation Scheme
	Development	**Outcome**
2007	Micro generation scheme for installations up to 5.75 kW of capacity. Participants in the General Case are paid a retail rate for excess generation. Participants in Bonus Case are paid an initial FiT of 0.65€/kWh further adjusted through time.	23 029 installations by 2013. 94.2 MW of installed capacity by 2014.
2008	Tax exemption for the first 5 000 € from electricity generated in mini generation regime.	
2010	Micro generation installations to consider condominium up to 11.04 kW. The Bonus Case model FiT is adjusted to 0.40€/kWh further adjusted through time.	
2013	The General Case model is adjusted allowing for a new method of calculation or for electricity to be traded in organized markets or bilateral contracts.	
2014	Mini generation scheme repealed	
Year	**Support Policy**	Mini Generation Scheme
	Development	**Outcome**
2011	A mini generation scheme is implemented above the micro generation limits and up to 250 kW of capacity. Participants in the General Case are paid per market prices. Participants in the Bonus Case are paid a set FiT OF 0.25€/kWh for installations ≤ 20kW and a bid based FiT for installations above 20kW.	986 installations by 2013. 64.5 MW of installed capacity by 2014.
2013	The General Case model is adjusted considering electricity system costs.	
2014	Micro generation scheme repealed	
Year	**Support Policy**	Self-consumption scheme
	Development	**Outcome**
2014	Implementation of Self-consumption scheme, aiming at supplying local demand needs, with the possibility to inject electricity into the grid. Participants with systems	21.4 MW of installed capacity by 2015.

	above 1.5 kW are subject to fixed fee for covering system costs.	
Year	**Support Policy**	Small-scale production scheme
	Development	**Outcome**
2014	Implementation of Small-scale production scheme. Producers are assigned a FiT through a bidding process with a reference FiT between 0.095€/kWh and 0.11€/kWh	8.8 MW of installed capacity by 2015.

As it can be seen, both countries present completely different supporting policies. Portugal, on the one side, adopted feed-in tariffs in order to promote an accelerated diffusion of photovoltaic distributed generation, reflecting mainly the necessity of meeting environmental policy goals. Brazil, on the other side, implemented a net-metering scheme, with more conservative rules, in response to the fact that it already counts with a high share of renewable sources in its matrix, so reducing carbon emissions is not a priority for its energy policy.

In this context, it's worth noting that Portugal presents better results, in terms of technology diffusion, which becomes clear when comparing the photovoltaic installed capacity in the countries. While Portugal evolved from an installed photovoltaic capacity of 10.7 MW, in 2008, Brazil only reached this amount in 2014. By the end of 2015, Portugal reached a capacity of 189.8 MW, while Brazil, by the second half of 2016, still has a capacity of 42.9 MW.

It must also be considered that Portugal is facing barriers related to the cost of the policy, which, associated to the competitiveness stage the technology reached in the country, demanding lower levels of support, lead to the drastic reduction of the incentives. Brazil, on the other hand, is improving and expanding its policy, in order to create better conditions to the development of the technology.

5. CONCLUSIONS

Despite different contexts and energy policy goals, both Brazil and Portugal are still in the process of adapting and refining their photovoltaic supporting policies toward their market development needs.

Portugal adopted a feed-in scheme, reaching higher diffusion level, but is in the process of reducing government support measures, as a reaction to the growing policy costs, and the falling costs of the technology. Brazil, in contrast, initially opted for a more conservative policy and implemented a net metering system, with strict rules, reaching much lower levels of diffusion, and is now evolving to the creation of more favourable terms to photovoltaic market development.

However, despite Portuguese policy seems to be superior on a first sight, the distinct development level of the policies might not be neglected. While there are just four years since Brazilian net metering was implemented, it has been almost one decade since Portuguese

support scheme was adopted. This issue raise questions about how much the development stage, and consequently the path dependence dimension, affects the policies outputs.
Therefore, it is important to highlight that the analysis of the supporting policies, itself, is essential, but not enough to explain the difference between the cases, as other factors such as technology costs, credit access conditions and the motivations to support these policies are also important in explaining the policies results. Although these differences are not in the scope of the present work, they will be further discussed in future studies.

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