CLIMATE POLICY INITIATIVE
NÚCLEO DE AVALIAÇÃO
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Developing Brazil's Market for Distributed Solar Generation

CPI study highlights the need to address demand-side factors in policies to promote renewable energy

Brazil meets almost 45% of its energy demand through renewable resources.[1] While this makes the nation's energy supply one of the least carbon-intensive in the world, the increase of non-renewable sources in the Brazilian energy matrix from 2005 to 2015 highlights the challenge the nation faces in meeting its climate goals.

Renewable resources are at the center of the discussion on how to move towards a clean and reliable energy system around the world and are seen as a key instrument in combatting greenhouse gas emissions and climate change. Analysis to date points to the availability of renewable natural resources as the main determinant of a nation's ability to reduce climate risk.[2]

However, new analysis by researchers at Climate Policy Initiative/ PUC-Rio (CPI) shows that **the development of the renewable energy sector occurs not only through the availability of natural resources, i.e., determinants of supply, but also through aspects of demand, such as income, population and electricity tariff.**

Measurements of solar radiation indicate that Brazil receives more than enough sunlight to meet the nation's projected energy demand through the use of photovoltaic (PV) energy generation, which converts sunlight to electricity.[3] Given this supply of sunlight for Brazil, the challenge to reaping its benefits lies in the nation's ability to develop demand-side opportunities that encourage reliable solar generation and active markets.

Brazil especially holds potential for advancing its level of solar energy through distributed generation, which generates power on-site at the point of consumption, i.e., in a decentralized way, and has a small, but established market in parts of the country. By moving away from large, centralized plants, the country could reduce the costs, complexity, interdependencies, and inefficiencies associated with transportation.

In this new study, CPI researchers analyzed 5,563 municipalities in Brazil and show that demand-side factors drive consumer uptake of PV distributed energy generation. This effect is so relevant that municipalities with lower annual solar radiation have, on average, more consumer units of distributed solar photovoltaic generation than municipalities with higher levels of radiation.

This CPI study is one of the first to examine the decentralized solar generation market at a municipality level, yielding unique insights to this emerging industry.

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1 EPE, 2017. *Brazilian Energetic Review 2016*.

2 IPCC, 2014. *Climate Change 2014: Synthesis Report*. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

3 EPE, 2014. *Inserção da Geração Fotovoltaica Distribuída no Brasil – Condicionantes e Impactos*. Nota Técnica DEA 19/14, Ministério de Minas e Energia.

Smileus/Depositphotos.com

KEY FINDINGS

- Municipalities with lower annual solar radiation have, on average, more consumer units with distributed solar photovoltaic generation than municipalities with higher annual radiation levels.
- Municipalities with higher Gross Domestic Product (GDP), population, and electricity tariffs have greater numbers of photovoltaic units in Brazil.
- Only 1,478 municipalities out of the 5,563 municipalities studied had at least one photovoltaic solar unit in 2017.
- The highest number of photovaltaic units in a single municipality was 436 in Rio de Janeiro in June 2017.

KEY RECOMMENDATIONS

- Target policies on renewables aimed at climate risk mitigation to address demand-side factors such as income, population and electricity tariff, in addition to promoting supply-side availability of natural resources.
- Consider how the differences in tariffs across the country may have consequences on the penetration of photovoltaic between different regions of the country.
- Incorporate the promotion of renewable energy sources into development strategies that address the poorest regions of the country, which also have the highest solar potential.

ANALYSIS FOR POLICYMAKERS

Overview of the Solar Generation in Brazil's Electricity Matrix

In Brazil's current electricity matrix, photovoltaic solar expansion is still in its early stages. Solar generation occurs in centralized systems, which are large solar power plants, and in decentralized systems where consumers install or share installation and management of units. Table 1 presents the number of units and capacity by generation type in both systems.

Table 1: Brazil's Renewable and Nonrenewable Power Supply – Units and Capacity by Type

	Centralized			Decentralized		
	# Plants	Power (kW)	%	# Units	Power (kW)	%
Hydroelectric	219	93,216,340	61.1%	-	-	-
Thermal	2,926	41,021,055	26.9%	51	19,187	14.6%
Wind	439	10,701,743	7.0%	52	10,183	7.7%
Small Hydro Plant	434	4,976,230	3.2%	-	-	-
Thermonuclear	2	1,990,000	1.3%	-	-	-
Super Small Hydro Plant	613	546,491	0.4%	15	11,253	8.5%
Solar Photovoltaic	50	144,214	0.1%	11,365	91,038	69.2%
Total	**4,683**	**152,596,073**	**100.0%**	**11,483**	**131,661**	**100.0%**

Source: ANEEL, June 2017

Overall, centralized solar energy generation represents just 0.1% of the nation's centralized electricity matrix, while thermoelectric and hydroelectric plants still represent almost 90% of the generation supply.

However, the decentralized solar generation market currently makes up almost 70% of the decentralized supply and almost all of the installed consumer units at 99%. This level of consumer interest in decentralized solar energy suggests a great potential for the growth of this renewable.

Moreover, distributed generation also has the potential to reduce investments in the expansion of transmission and distribution systems, lower environmental impacts, reduce load networks, and diminish transportation losses.

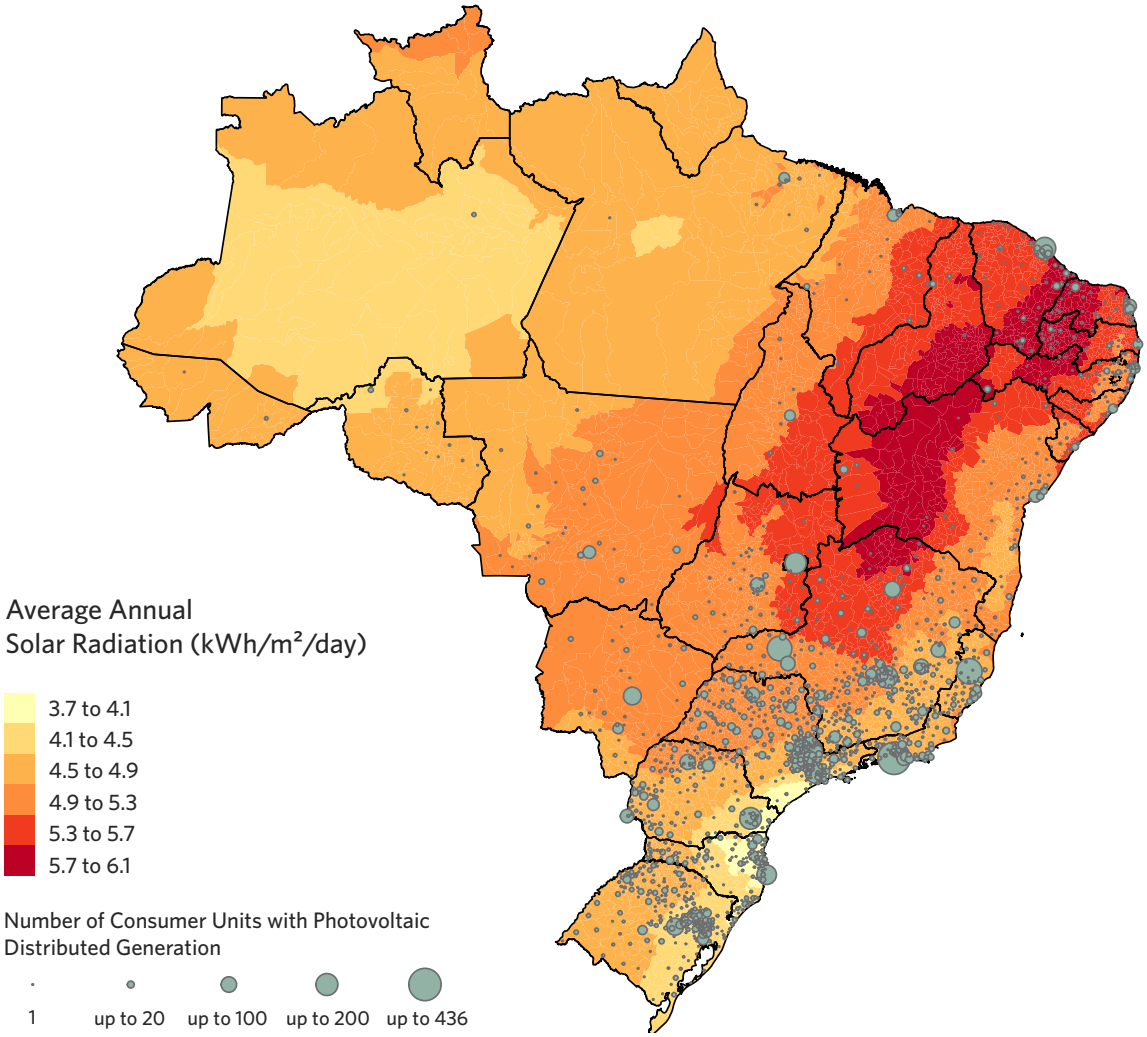
Characteristics of Brazil's Decentralized Solar Photovoltaic Market

Location and Solar Radiation

In an optimally-designed system for solar energy generation, units would be located in the prime areas for solar radiation because this directly affects panel output.

However, as Figure 1 illustrates, the regions with the greatest numbers of consumer PV generation units are not necessarily those with the highest levels of solar radiation.

Figure 1: Average Annual Solar Radiation and Consumer Units with Photovoltaic Distributed Generation per Municipality in Brazil



Source: ANEEL, LABREN, CCST and INPE, 2017

On the contrary, the map shows that PV units are mainly concentrated in the Southeast and South. These areas have minor solar potential when compared to the Center and Northeast regions.

Data show that, in Brazil, areas with higher levels of sunlight have lower numbers of consumer units with photovoltaic generation. These results suggest that the development of the renewable energy sector occurs not only through matching of solar supply to generation, but also through aspects of demand.

The Role of Demand – Tariffs, GDP, and Population

While solar radiation supply varies throughout the nation, distributed generation is viable even in areas that receive the lowest levels. CPI researchers show that demand-side factors, such as Gross Domestic Product (GDP), population size, and the electricity tariffs, also influence where distributed generation is found throughout the country by increasing the number of PV units.

Consumers and Distributed Generation

To understand these demand patterns for distributed generation, it is helpful to review how consumers participate in the distributed solar generation market. Currently, Brazilian consumers can generate their own electricity from renewable resources. They can then provide the surplus produced to the distribution network at their location. In the net metering systems, a consumer of electricity installs small generators in their consumer unit and the energy generated is used to reduce the electricity consumption of the unit.

Recent regulations authorized states to exempt customers from paying the electricity tariff on the value of the energy they consume from the distributor if it corresponds to the number of energy credits they obtained through their net metering. This has helped encourage expansion of the market.

Distributors, Tariffs and Distributed Generation

The distribution of the public electricity is carried out by 63 concessionaires and 38 permissionaires.[4] These distributors are regulated by the government through the Brazilian Electricity Regulatory Agency (ANEEL). Distributors cannot set their own prices and the electricity tariff is fixed for each distributor; the decision is based on characteristics of the distributor's concession area, such as the number of consumers, market density, and cost of purchased electrical power.

CPI researchers identified that the higher the electricity tariff in the municipality, the greater the incentive to invest in photovoltaic panels to generate power. They also show that the larger the population in the municipality, the larger the number of solar generation units. The higher the municipal incomes, the larger the number of consumers with resources to invest in the installation of panels and, thus, the larger the number of units with distributed generation.

This is not to say that higher solar radiation does not play a role. When CPI researchers looked more closely at what was happening in each concession area, they determined that when considering these demand factors and the specific incentive policies of each distribution company, higher solar radiation will significantly increase the number of consumer solar generation units.

CONCLUSION

These results highlight that the availability of natural resources alone is insufficient for increasing the adoption of PV units in Brazil. This has important policy implications for the nation as it seeks to boost the role of renewables in its energy matrix. CPI analysis reveals that the design of renewables policies aimed at climate risk mitigation must consider demand-side factors such as income, population and electricity tariff, in addition to supply-side availability of natural resources. Policymakers must also work to incentivize take-up in areas throughout the nation that have the highest solar energy potential.

4 According to article 2 of the Concessions Law (Law no. 8987/95), Concessions and Permissions are public service delegations made by the government under a bidding process. The difference between concession and permission refers to the contract's stability. Concessions are more secure, since the services they refer to require more upfront investment.

Notes on Data

The empirical analysis is based on a cross-section of 5,563 municipalities built entirely from publicly available data and combining information from three main sources identified below.

- Number of consumer units with photovoltaic distributed generation, electricity tariff, and information about the electricity distributors in each municipality obtained from ANEEL (June 2017).
- Solar radiation from National Institute for Space Research (INPE), from the Laboratory of Modeling and Studies of Renewable Energy Resources (LABREN), and the Earth System Science Center (CCST) (July 2017).
- Data for municipal Gross Domestic Product (in R$ 1,000) and population taken from Brazilian Institute for Geography and Statists (IBGE) (2012).

Missing data for seven municipalities (Fernando de Noronha, Nazária, Pescaria Brava, Balneário Rincão, Mojuí dos Campos, Pinto Bandeira, and Paraíso das Águas) imposed a sample restriction. In 2017 there were 5,570 municipalities in the country total.

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