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IS THE FUTURE OF BRAZILIAN MICRO AND MINI-GENERATION PV SYSTEMS CLEAR?

Authors:
Bruno Moreno Rodrigo de Freitas: Researcher at Fundação Getulio Vargas, Centro de Estudos FGV Energia.
Contact information: bruno.freitas@fgv.br Tel.: (21) 3799-6100.
Rafael da Costa Nogueira: Researcher at Fundação Getulio Vargas, Centro de Estudos FGV Energia.
Contact information: rafael.nogueira@fgv.br Tel.: (21) 3799-6100.

Abstract:

Decentralized energy generation is current trend for power plant expansion worldwide. In Brazil, ANEEL’s Normative Resolution 482 (NR 482), which establishes Net Energy Metering System as the country’s metering benchmark, and defines the characteristics of mini and microgeneration systems, represents an important step towards increasing decentralized generation feasibility. The present paper aims at assessing the financial viability of microgeneration for photovoltaic (PV) systems for a hypothetic residential consumption. We have built different scenarios concerning i) household localization; ii) annual tariff readjustment; iii) source of financing; and iv) technology cost reduction. We have found that most of the appealing investment outcomes are from 100% debt under Construcard loan.

Keywords: NR 482, Microgeneration, PV Systems, Financial Viability Scenarios.

1. INTRODUCTION

Decentralized generation, also known as distributed generation, is already a reality in many countries, and is pointed out as the future of electricity generation in the upcoming years. Social and environmental barriers, together with high transmission costs and high energy losses have made centralized energy arrangements more challenging, opening opportunities for the insertion of new energy production approaches (Carley, 2009). As a result, generation expansion has increasingly focused on decentralized arrangements.

But, what is the precise definition of decentralized generation? Some authors[1] define it as "a small power generation unit, based on new energy and renewable energy and located near the load". Nonetheless, according to Pepermans et al. (2005), there is not a unique definition, and what will be considered decentralized generation will depend on the policy adopted by the government. Some countries define decentralized generation on the basis of the voltage level, whereas others establish it taking into consideration some basic characteristic such as: renewable, cogeneration, not centrally dispatched.

Many governments[2] have modified their energy policies in order to speed up the development and usage of decentralized energy technologies. Usually, those policies start with a financial mechanism for those interested in investing on such technologies. As bottlenecks are alleviated, due to technology standardization and achievement of the energy policy agenda's milestones, the government gradually reduces the incentives.

Besides government subsidies, grid parity is another appeal for decentralized energy technology promotion. According to Holdermann et al. (2014) when the levelized cost of energy generation hits the price of electric energy from the local grid, then the energy policy adopted has reached its main goal, the grid parity. In this way, the consumer can choose what suits its best: the energy from the grid, which is a mix of energy sources; or a small scale installation chosen by the consumer, amongst many social-environmental friendly technologies. Grid parity can be a measurement of how mature a market is in the insertion of a type of decentralized energy system generation. As Olson and Jones (2012) have remarked, "grid parity has long been the holy grail of the renewables industry".

Brazil has followed the international trend towards decentralized generation. In Brazil, the definition of micro and minigeneration was given by the National Electricity Regulator, ANEEL, in resolution 482 (NR 482). This piece of regulation also states many other aspects of decentralized generation, and can be viewed as a first incentive policy for decentralized generation[3] in Brazil. For example, before the resolution, projects dependent on intermittent energy sources needed a backup system to store the

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[1] Ackermann & Knyazkin, 2002 *apud* Vahl, et al., 2013
[2] For example, the European Union when they launched their 20-20-20 target.
[3] Since decentralized energy generation is a general concept and has many definitions, in this paper we will treat it as microgeneration system according to NR 482.

non-consumed energy at the moment of generation. However, storage systems as batteries are still expensive, increasing the costs of projects and reducing their financial viability.

Although the legal apparatus support from NR 482 helps planning new investments on micro and microgeneration, there are still financial issues associated with starting those projects. Since Brazil is a new market for this type of generation, and there are lots of uncertainties that should be taken into account by the consumer/investor, is it financially feasible to finance a PV system for a hypothetic consumer in some specific cities? In other words, do PV systems yield positive returns to the required investments?

The present study aims at answering that question, modelling a PV microgeneration system and discounting the monthly cash flow (DCF), for a hypothetic residential consumption, based on the analysis of different scenarios, including: localization, technology standardization, capital structure and annual tariff readjustment. Although there is a trully developed PV energy market in some countries, the Brazilian one is still undeveloped and presents significant obstacles for its full development.

This paper is organized as follows: section 2**Erro! Fonte de referência não encontrada.** discusses NR 482 and presents some background regulation of distributed generation in Brazil. Section 3 describes the methodology, and presents the (technical and financial) assumptions and the scenarios analyzed. Simulations and results are shown in section 4, while section 5 concludes.

2. Regulatory Framework – Normative Resolution 482 (NR 482)

On April 17th, 2012, ANEEL launched the Normative Resolution 482, which establishes some definitions and sets up a policy towards some sorts of decentralized generation systems. That new approach aimed to stimulate the growth of a new arrangement of energy production. Instead of having few large power plants, the motion is to spread the generation units and have the energy production from renewable sources closer to the load.

Some aspects of that policy are discussed in NR 482. First, it defines micro and minigeneration as energy systems with installed capacity up to 100 kW, and from 100 kW up to 1 MW, respectively. It also includes the usage of different energy sources, such as hydro, biomass, solar, wind, or qualified cogeneration. Second, NR 482 establishes the use of the Net Energy Metering (NEM) system, a mechanism which allows for the energy produced in excess to be injected into the grid of the local distribution company. In this system, the volume (in kWh) of electricity injected compensates for the volume of energy consumption for the unit, and the consumer is charged for the net amount energy metered. Any energy surplus becomes a credit in terms of energy units, which can be discounted in a time frame limit of thirty six months. In other words, if a consumer has installed a micro or minigeneration system that has produced more energy than consumed, that energy can be injected into the grid, serving as "energy storage", and can be taken afterwards, whenever desired. Still, if another consumption unit is listed in the name of the same individual taxpayer registry (CPF), or in the same national corporate taxpayer registry (CNPJ), it is possible to use the energy credit of that unit (ANEEL, 2012).

Current regulation clearly states that the excess of energy injected in the grid should be treated as a temporary "loan" to the local distribution company – therefore, should not be subject to taxation. Yet, the Federal Tax Council (CONFAZ), which establishes the tax rate on services and goods, including energy, has another interpretation. CONFAZ's decision was to tax the gross energy consumption, instead of the net energy. That decision reduces the financial viability of most of photovoltaic mini and microgeneration projects, particularly those which remain consuming energy from the grid. However, the present paper does not take into consideration CONFAZ's decision, which is still under discussion.

3. Methodology and Assumptions

3.1. Technical Assumptions

The Brazilian electric energy sector distinguishes the consumers between high voltage (class A) and low voltage (class B). The energy tariffs paid by each type of consumer are different. For those who belong to class A, a seasonal time-of-day tariff is applied. However, class B consumer pays a unique tariff defined by ANEEL to the energy distribution company (EDC). Within class B consumer type, there are subclasses: B1-Residential, B2-Rural, B3-Other subclasses[4] and B4-Public illumination.

The present paper aims to be a valuable source of information for a residential consumer that wants to install a microgeneration small-scale PV system, according to current NR 482. In this way, the focus of the paper is to assess the technical and financial viability for a B1 class consumer. Moreover, class B1 splits into regular and social tariffs - the last being meant for the low income population. Since the costs of microgeneration are still high in Brazil, the evaluation considered a high medium class as the hypothetic consumer/investor, who pays a regular tariff and has an average consumption of 500 kWh per month.

We have calculated the viability according to the financial hypothesis described further in section 3.2. However, first it was necessary to establish a system dimension calculation methodology. The first step was to set the annual consumption (C_a). Since the average electricity demand for the hypothetic consumer was 500 kWh per month, we calculated the project for a consumer with an annual average consumption of 6,000 kWh.

The module features were adopted according to reasonable realistic values. For the present case, the efficiency adopted was 14.8% (η_{mod}), and the nominal module power was 245 Wp. The performance ratio (PR_{GTPhS}) is a parameter that describes the total losses of the whole system, including voltage drop, dirt on the panels, shading, inverter efficiency, operational temperature etc. In Brazil, a reasonable value for PR_{GTPhS} is 80% (CEPEL, 2014). Each module had an area (S_{mod}) of 1.6 m², which is a standard size. The locations evaluated were the cities of Rio de Janeiro, São Paulo, Campinas and Curitiba, for financial issue reasons enlightened in subsection **Erro! Fonte de referência não encontrada.**. The values for local solar irradiation (I_{IP}) are shown in Table 1 :

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[4] Industrial, commercial, services and other activities, public service and self-consumption.

Table 1: Solar Irradiation for the assessed locations

City	Latitude [°]	Longitude [°]	kWh/m²/year
São Paulo	23,5° S	46,6° W	1511
Curitiba	25,3° S	49,3° W	1413
Campinas	22,8° S	47,0° W	1887
Rio de Janeiro	22,9° S	43,2° W	1559

Source: (Own elaboration based on data from CEPEL)

A good approximation of the system size can be calculated by the following equations[5]:

$$W_{GTPhS} = \frac{C_a * W_{mod}}{I_{IP} * \eta_{mod} * PR_{GTPhS} * S_{mod} * 1000} \tag{1}$$

$$N_{mod} = \frac{W_{GTPhS}}{W_{mod}} \tag{2}$$

$$S_{GTPhS} = S_{mod} * N_{mod} \tag{3}$$

The parameters of the equations are described in Table 2:

Table 2: Parameter Explanation

Parameter		Unit	Parameter		Unit
η_{mod}	Module Efficiency	%	**W_{GTPhS}**	System Nominal Power	kWp
PR_{GTPhS}	Performance Ratio	%	**C_a**	Annual Consumption	kWh/year
S_{mod}	Module Area	m²	**N_{mod}**	Number of modules	Quantity
W_{mod}	Module Nominal Power	Wp	**S_{GTPhS}**	Global System Area	m²
I_{IP}	Irradiation of Inclined Plane	kWh/m²/year			

Source: Own elaboration

The costs of equipment may present a wide range, mainly in Brazil, where the market does not present a complete photovoltaic production chain. The price of each component was basically researched on the internet. However, a realistic value according to SOLARIZE (2013) was adopted afterwards. Table 3 describes the marginal cost of the equipment and the mentioned required input data:

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[5] The calculation is an approximation and should not be taken as a final definition of the project. A deep study must be done by competent professionals. Nonetheless for the present study, the model is satisfactory.

Table 3: Input Data Adopted

Parameter	Values
Module Eficiency	14.80%
Performance Ratio	0.8
Annual Loss Ratio	0.75%
Module Length	1.6 m
Module Width	1 m
Module Area	1.6 m²
Module Nominal Power	245 Wp
Module Costs	4 R$/Wp
Inverter Costs	1.4 R$/Wp
Installation and Mounting System Costs	1.83 R$/Wp
Engineering Services Costs	10.00%

Source: Own elaboration based on data from CEPEL (2014) and SOLARIZE (2013)

Once the input data was set, we calculated through the equations (1), (2), and (3) the project's dimensions, as well as the total cost of the system. Equation 1 expresses that the total capacity of the system is a dependent variable on the local solar irradiation. As we assessed four locations, with different solar irradiations, *ceteris paribus*, we obtained four system configurations as follows in Table 4:

Table 4: Dimension of the Systems

Output	Assessed Locations			
	São Paulo	Curitiba	Campinas	Rio de Janeiro
System Nominal Power (W_{GTPvS})-kWp	5.1	5.5	4.1	5.0
Module Quantities (N_{mod})	21	22	17	20
Total Area (S_{mod})-m²	33.50	35.89	26.83	32.53
Total Costs	R$ 40,790.52	R$ 43,707.89	R$ 32,677.09	R$ 39,611.88
Specific Investment-R$/kWp	R$ 7,953.00	R$ 7,953.00	R$ 7,953.00	R$ 7,953.00
Specific Cost of Generation-R$/kWh	0.3719	0.3980	0.2976	0.3608

Source: Own elaboration

3.2. Financial assumptions

Besides the risks on the amount of solar irradiation available, the decision on financing a solar photovoltaic project must also allow for other types of risks, such as financial and economic ones. For the financial viability assessment, we proposed a calculation based on the net allocation of the energy consumed and generated by the dimensioned PV systems, according to NR 482 specifications. For tractability of the model, the monthly consumption profile was fixed and kept the same every year during the lifetime of the project. Moreover, the consumption profile was the same for the locations assessed through the years as well. Since the annual average solar irradiation is different for the four locations assessed, we obtained four different PV systems as previously seen in Table 4.

We have valued the projects using a DCF methodology. For the monthly cash flow of operation (MF) calculation, we used the following figures: i) as monthly revenues, the self-consumption and energy injections into the grid, and the accrued credits from previous months; ii) as monthly costs, the consumption from the local grid[6]. The cash flow horizon was 300 months, because the usual producer's warranty for PV modules is 25 years[7]. The local energy supplier's tariff[8] applies to the net consumption, which will be the electricity bill for the consumer/investor. Even though all the energy consumed is supplied by the PV system, the consumer pays at least the availability cost[9].

Besides the monthly incremental cash flow from the operational activities, we should evaluate the project considering its opportunity cost. The monthly opportunity costs (MOC) for this project were the monthly fixed income that the consumer gives up to invest.

We have also added the annual cost for operation and maintenance (O&M – Energy policy), and the cost for the inverter replacement (Inv) every 120 months. The 10 years horizon also followed usual warranty of inverter producers[10]. The project was then evaluated by its profitability index (PI). The PV system is financially worth doing when its PI is greater or equal than 1. If else, there are no positive returns for a 25 years horizon project. The PI is simply:

$$PI = \frac{\sum_{\gamma=1}^{300}\frac{MF_\gamma - MOC_\gamma}{(1+i)^\gamma} - \sum_{\alpha=13}^{289}\frac{O\&M_\alpha}{(1+i)^\alpha} - \sum_{\theta=121}^{241}\frac{Inv_\theta}{(1+i)^\theta}}{I_0} \tag{4}$$

Where:

$I_0 = Initial\ Investment;$

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[6] Revenues and costs are in energy unit kWh.

[7] See sample at http://eng.sfe-solar.com/wp-content/uploads/2012/05/SunFields_SHARP_Datasheet_ND-R-230-235-240-245-250A5_EN.pdf.

[8] The tariff used will consider only the pure energy tariff launched by ANEEL, taxed with the respective ICMS of the state, and an average of 2.25% of PIS/COFINS.

[9] Availability Cost = (100kwh*tariff), with taxes.

[10] See sample at http://files.sma.de/dl/4776/SUNNYBOY3384-DUS143033W.pdf.

$$MF_{\gamma} = Monthly\ Cash\ Flow\ From\ Operation\ at\ month\ \gamma;$$

$$MOC_{\gamma} = Monthly\ Opportunity\ Cost\ at\ month\ \gamma;$$

$$O\&M_{\alpha} = Operation\ and\ Maintanance\ Cost\ at\ month\ \alpha;$$

$$Inv_{\theta} = Inverter\ Equipment\ Cost\ at\ month\ \theta;$$

$$\gamma \epsilon \{ \mathbb{N}^{*} | \gamma \leq 300\}; \alpha \epsilon \{ \mathbb{N}^{*} | \alpha = 13 + 12(\gamma - 1) \wedge \alpha \leq 289\} ; \theta = [121; 241].$$

Departing from a base scenario for the cities analysed, this section also discusses different ways of financing the project for the hypothetic consumer, according to built scenarios for tariff readjustments, and technology standardization (decrease in initial investments for PV Systems).

3.3. Base case and Built Scenarios

3.3.1. Base case

Our model had a base case scenario for each city analysed. The base case scenario considered the current tariff and VAT tax rates (ICMS) (Table 5), the Total Costs (at Table 4) for the project as initial investment (I_0), and 100% of self-financing. The monthly opportunity costs were the fixed income (CDI) returns[11] for amount of self-financed initial investment. Besides different tariffs and ICMS tax rates, and I_0 for the four cities, the cost for self-financing is also different for each location. Thus, we also needed to calibrate the base case self-financing scenarios for each city. Table 5 gives the current tariffs and tax rates for the EDCs used in the base scenario.

Table 5: EDC's tariffs and ICMS tax rate

EDC	Tariffs (R$/kWh)	Consumption Range (kWh) and ICMS Tax Rate
Eletropaulo	0,37182	$Cm < 90 \rightarrow Exempt; 90 \leq Cm < 200 \rightarrow 12\%; Cm \geq 200 \rightarrow 25\%$
CPFL	0,40300	$Cm < 90 \rightarrow Exempt; 90 \leq Cm < 200 \rightarrow 12\%; Cm \geq 200 \rightarrow 25\%$
Light	0,46858	$Cm < 50 \rightarrow Exempt; 50 \leq Cm < 300 \rightarrow 18\%; Cm \geq 300 \rightarrow 29\%$
COPEL	0,43037	$Cm < 30 \rightarrow Exempt; Cm \geq 30 \rightarrow 29\%$

Source: Own elaboration based on data from ABRADEE and ANEEL

When self-financing, the most challenging attribution for a project viability analysis is the estimation of its cost of capital. The risks associated with a small project are even harder to estimate, because of lack of data for a similar situation. Therefore, we

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[11] We used an annualized real interest rate of 6.06%

have modelled the hypothetic consumer/investor as if it were a small energy distribution company (EDC). Then, we have estimated its cost of equity for the project using the listed local EDCs as proxy.

The decision for using an EDC as proxy, instead of an energy generation company, was a result of the financial risks associated with the project. Those risks are based on the business relationship between the hypothetic consumer/investor and the EDC. That relationship stems from the incentive policy designed through NR 482 with NEM System, which aligns it with the distribution activity.

The companies COPEL, Light, Eletropaulo and CPFL are the four EDCs used in this study, because they have high trade papers at IBOVESPA. Other listed EDCs do not have high market liquidity for their stocks. So, we have chosen not to study other Brazilian cities. We have then estimated each cost of equity using CAPM model.

There is a trade-off when choosing the timeframe for beta estimation using CAPM. Larger data represents more observations in the regression; however, we may be incorporating some company's characteristics, or even sector's, which have changed over the time (Damodaran, 2012). The Provisional Measure n° 579 (MP 579, from September 2012) has changed the sector characteristics in terms of business revenues, by anticipating, and automatically renovating, the concession due date for signatories companies[12], under new tariff rules. We tested our data for three, two and one year time period, using daily returns[13]. The results from Shapiro-Wilk Normality test show that the Market's return does not have a Normal distribution for one and two-year horizon. Thus, we estimated the beta from CAPM for a three-year horizon as shown in Table 6:

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[12] COPEL is not a signatory for MP 579. For the sake of equal comparison, the timeframe for beta estimation was the same for the four companies analyzed.

[13] We used daily IBOVESPA returns as proxy for market returns, and daily CDI (One-Day Interbank Deposit) returns as proxy for risk free returns. Bloomberg tickers for companies' stocks analyzed are: LIGT3 (Light), CPLE6 (Copel), CPFE3 (CPFL), and ELPL4 (Eletropaulo).

Table 6: Shapiro-Wilk Normality Test Results

Time	Companies*				Market*	Risk free*
Frame	Light	COPEL	CPFL	Eletropaulo	Ibovespa	CDI
1 yr	Normal	Not-normal	Not-normal	Normal	Not-normal	Normal
2 yr	Normal	Normal	Normal	Normal	Not-normal	Normal
3 yr	Normal	Normal	Normal	Normal	Normal	Normal

Source: Own elaboration based on data from Bloomberg
***Daily returns**

The beta estimated[14] is the business risk, compared to the systematic risk, and should translate the risks associated to the electricity distribution business. The historic beta also takes into account the company's financial leverage level. Since our hypothetic consumer/producer is a household, we needed to unlever the beta in order to make it more realistic for our study. In Table 7 it is possible to follow the betas calculated for each EDC, as well as the return rates in real prices:

Table 7: EDCs' Betas, equity, debt and return rate

	Company			
	Light	COPEL	CPFL	Eletropaulo
β levered*,**	0.50	0.43	0.50	0.29
β unlevered***	0.23	0.33	0.22	0.16
Ep****	3,628.63	13,682.78	8,798.72	2,567.81
D****	6,582.30	6,054.40	17,021.40	3,071.89
Return Rate	7.38%	8.13%	7.30%	6.85%

Source: Own elaboration based on data from Bloomberg
***p<0.05;**p<0.01;**
*****β unlevered = β levered/[1+D/Ep*(1-t)].**
****** In R$ million.**
Ep = total equity; D = total debt; t = taxes = 34%

3.3.2. Built Scenarios

3.3.2.1. Tariff Readjustments and Technology Standardization

The energy tariff in Brazil is revised and adjusted periodically within the regulatory process, based on the rules defined by the regulator, ANEEL, so as to establish a fair value for operational costs variation and inflation movements. Since the financial viability is directly proportional to the level of tariffs, we assessed the viability with the tariff increases ranging from 1% p.a. up to 6% p.a., in real terms. We have simulated scenarios for technology standardization as initial investment decrease, from

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[14] Outliers were identified as data lying outside the interval $\mu \pm 2\sigma$. We suppressed the observations with outliers' returns, even though the outlier datum was from the other three companies. We have done so in order to have the same number of observations for the four companies. Observations with outliers from IBOVESPA or CDI were also suppressed.

0% (i.e, base scenario) up to 50% reduction. The inflation rate used for real price transformations is based on the values mentioned in ANEEL (2015) – 5.03% p.a.

3.3.2.2. Different Costs of Capital

The hypothetic consumer/investor may finance the project with its own resources (100% equity), get a credit loan (100% debt), or even mix both types of sources of capital (WACC). The costs of PV microsystems in Brazil are still very high. The initial cost of those projects is approximately fifty times higher than the current Brazilian per capita income, for the sake of comparison. Thus, the option of getting loans to finance the photovoltaic system project becomes an opportunity to be evaluated.

For analysis purpose, we first checked the viability for a self-financing project (100% Equity). Next we did the same analysis, mixing equity and debt sources of capital, and assessed some WACCs for the project. Finally, we simulated a 100% debt financing scenario.

For the debt approach, we split the types of interest rates in two sorts: commercial banks and Construcard[15]. 49.20% p.a. is the interest rate assumed for commercial bank loans. It is the average of taxes from the commercial banks that offer “Other acquisitions” loan modality for individuals, according to Brazilian Central Bank. On the other hand, Construcard interest rate will vary according to individual features. For tractability, we adopted an average rate of 18.64% p.a. for the calculation based on Construcard’s website.

Table 8 sums up all the rates used to estimate the financial viability. The “Cost of Equity” column presents the discount rate for self-financing scenarios. WACC–CC is the WACC calculated using debt through Construcard modality, varying for 50% debt and 100% debt scenarios. WACC–CB follows the logic of WACC–CC, using debt through Brazilian commercial banks, instead.

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[15] Construcard is a program from the state-owned bank Caixa, which allows individuals to finance building materials, home repairs, etc. and recently has included the option of financing photovoltaic equipment.

Table 8: Rates Used for the financial viability assessment

City	Cost of Equity	Cost of Debt		WACC-CC		WACC-CB		Inflation
		CC	CB	50%	100%	50%	100%	
São Paulo	6.85%	18.64%	49.20%	10.18%	13.51%	21.26%	35.67%	5.03%
Campinas	7.30%	18.64%	49.20%	10.41%	13.51%	21.49%	35.67%	5.03%
Rio de Janeiro	7.38%	18.64%	49.20%	10.45%	13.51%	21.53%	35.67%	5.03%
Curitiba	8.13%	18.64%	49.20%	10.82%	13.51%	21.90%	35.67%	5.03%

Source: Own elaboration

CC - Construcard; CB - Commercial Bank; PS. 1: All the rates are per annum; PS. 2: Income tax: 27.5%

4. RESULTS

In Table 9 we build a heat map matrix crossing each scenario previously mentioned and compute PIs for each of them. Starting from the base case scenario, none of the location presents positive returns. The results become financially viable only with deeply technology standardization associated with high tariff readjustment. Among the locations assessed, Rio de Janeiro discloses the most appealing results, because of high solar irradiation, the highest level of tariff and low enough cost of equity.

Pinning Rio de Janeiro, we then analyse the financial viability through different costs of capital. Self-financing seems to be less appealing than WACC-CC simulation according to the number of viable scenarios, for both 50% and 100% of debt capital structure. That probably occurs because of the higher opportunity costs for self-financing. However, self-financing has more appealing results than WACC-CB. Due to opportunity costs, self-financing scenario is supposed to have less appealing results than WACC-CB. That does not happen because the benefits from lower (or none) opportunity cost are offset by very high cost of debt through Brazilian commercial bank loans. The same motion proportionally happens for the other locations. In other words, WACC-CC is always the best choice, followed by self-financing and WACC-CB.

An interesting point is Curitiba, which has as bad results as São Paulo. The first has higher energy tariff than São Paulo’s (including taxes), but its solar irradiation is the lowest among all cities. That result shows that both solar irradiation and financial features have leading roles in the viability analysis.

Table 9: Heat map matrix crossing multiple scenarios

			Energy Tariff Readjustments Scenario																							
			Curitiba						São Paulo						Campinas						Rio de Janeiro					
			1%	2%	3%	4%	5%	6%	1%	2%	3%	4%	5%	6%	1%	2%	3%	4%	5%	6%	1%	2%	3%	4%	5%	6%
System Costs Reduction	Self-financing	0%	-0.19	-0.13	-0.05	0.03	0.13	0.25	-0.29	-0.22	-0.13	-0.03	0.08	0.21	0.00	0.10	0.21	0.33	0.47	0.64	0.02	0.12	0.23	0.36	0.50	0.67
		10%	-0.10	-0.02	0.06	0.16	0.27	0.39	-0.19	-0.11	-0.01	0.10	0.22	0.37	0.13	0.24	0.36	0.50	0.65	0.84	0.15	0.26	0.38	0.52	0.68	0.87
		20%	0.02	0.11	0.20	0.31	0.43	0.57	-0.06	0.03	0.14	0.26	0.41	0.57	0.29	0.41	0.55	0.70	0.88	1.09	0.32	0.44	0.58	0.73	0.91	1.12
		30%	0.18	0.27	0.38	0.50	0.65	0.81	0.11	0.21	0.34	0.48	0.64	0.82	0.50	0.64	0.79	0.97	1.17	1.41	0.52	0.66	0.82	1.00	1.21	1.45
		40%	0.38	0.49	0.62	0.76	0.93	1.12	0.33	0.45	0.60	0.76	0.95	1.17	0.78	0.93	1.12	1.33	1.56	1.84	0.80	0.97	1.15	1.36	1.60	1.88
		50%	0.67	0.80	0.96	1.13	1.33	1.55	0.64	0.79	0.96	1.16	1.38	1.64	1.16	1.35	1.57	1.82	2.11	2.44	1.20	1.39	1.61	1.86	2.15	2.49
	WACC-Construcard (50% Debt)	0%	0.33	0.38	0.43	0.49	0.56	0.64	0.31	0.36	0.42	0.48	0.55	0.63	0.52	0.58	0.66	0.74	0.83	0.94	0.53	0.60	0.67	0.75	0.85	0.96
		10%	0.41	0.46	0.52	0.59	0.66	0.75	0.39	0.45	0.51	0.58	0.65	0.74	0.62	0.69	0.77	0.86	0.96	1.08	0.63	0.71	0.79	0.88	0.99	1.10
		20%	0.51	0.56	0.63	0.71	0.79	0.89	0.49	0.55	0.62	0.70	0.78	0.88	0.74	0.82	0.91	1.02	1.13	1.26	0.76	0.84	0.93	1.04	1.16	1.29
		30%	0.63	0.70	0.77	0.86	0.96	1.07	0.61	0.68	0.76	0.85	0.95	1.06	0.90	1.00	1.10	1.21	1.35	1.50	0.92	1.02	1.12	1.24	1.37	1.53
		40%	0.79	0.87	0.96	1.06	1.18	1.31	0.78	0.86	0.95	1.06	1.17	1.31	1.12	1.22	1.34	1.48	1.63	1.81	1.14	1.25	1.37	1.51	1.67	1.84
		50%	1.02	1.12	1.23	1.35	1.48	1.64	1.01	1.11	1.22	1.34	1.48	1.64	1.42	1.54	1.69	1.85	2.04	2.25	1.44	1.57	1.72	1.88	2.07	2.29
	WACC-Construcard (100% Debt)	0%	0.64	0.68	0.71	0.76	0.81	0.86	0.62	0.65	0.69	0.73	0.77	0.83	0.79	0.83	0.88	0.94	1.00	1.07	0.80	0.84	0.89	0.95	1.02	1.09
		10%	0.70	0.74	0.79	0.83	0.89	0.95	0.68	0.71	0.76	0.80	0.85	0.91	0.87	0.92	0.97	1.03	1.10	1.18	0.88	0.93	0.99	1.05	1.12	1.20
		20%	0.78	0.83	0.87	0.93	0.99	1.06	0.75	0.80	0.84	0.89	0.95	1.01	0.97	1.02	1.08	1.15	1.23	1.32	0.98	1.04	1.10	1.17	1.25	1.34
		30%	0.89	0.93	0.99	1.05	1.12	1.20	0.85	0.90	0.95	1.01	1.08	1.15	1.09	1.16	1.23	1.31	1.40	1.50	1.11	1.18	1.25	1.33	1.42	1.52
		40%	1.02	1.08	1.14	1.22	1.30	1.39	0.98	1.04	1.10	1.17	1.24	1.33	1.27	1.34	1.42	1.52	1.62	1.74	1.28	1.36	1.45	1.54	1.65	1.77
		50%	1.21	1.28	1.36	1.44	1.54	1.65	1.16	1.23	1.30	1.39	1.48	1.58	1.50	1.59	1.69	1.80	1.93	2.07	1.53	1.62	1.72	1.83	1.96	2.11
	WACC-Commercial Bank (50% Debt)	0%	0.20	0.21	0.23	0.25	0.27	0.29	0.19	0.21	0.22	0.24	0.26	0.28	0.30	0.32	0.34	0.37	0.40	0.43	0.31	0.33	0.35	0.38	0.40	0.43
		10%	0.24	0.26	0.28	0.30	0.32	0.34	0.23	0.25	0.27	0.29	0.31	0.33	0.35	0.38	0.40	0.43	0.46	0.49	0.36	0.38	0.41	0.44	0.47	0.50
		20%	0.29	0.31	0.33	0.35	0.38	0.41	0.28	0.30	0.32	0.34	0.37	0.40	0.42	0.44	0.47	0.50	0.54	0.57	0.42	0.45	0.48	0.51	0.55	0.58
		30%	0.35	0.38	0.40	0.43	0.45	0.49	0.34	0.36	0.39	0.41	0.44	0.48	0.50	0.53	0.56	0.60	0.63	0.68	0.51	0.54	0.57	0.61	0.65	0.69
		40%	0.44	0.46	0.49	0.52	0.56	0.59	0.43	0.45	0.48	0.51	0.54	0.58	0.61	0.64	0.68	0.72	0.77	0.82	0.62	0.66	0.69	0.74	0.78	0.83
		50%	0.56	0.59	0.62	0.66	0.70	0.74	0.54	0.57	0.61	0.65	0.69	0.73	0.76	0.81	0.85	0.90	0.95	1.01	0.78	0.82	0.86	0.91	0.97	1.03
	WACC-Commercial Bank (100% Debt)	0%	0.25	0.26	0.26	0.27	0.28	0.28	0.24	0.25	0.25	0.26	0.27	0.27	0.31	0.32	0.33	0.34	0.35	0.36	0.32	0.32	0.33	0.34	0.35	0.36
		10%	0.27	0.28	0.29	0.30	0.30	0.31	0.26	0.27	0.28	0.28	0.29	0.30	0.34	0.35	0.36	0.37	0.38	0.39	0.35	0.36	0.37	0.38	0.39	0.40
		20%	0.30	0.31	0.32	0.33	0.34	0.35	0.29	0.30	0.31	0.32	0.33	0.34	0.38	0.39	0.40	0.41	0.43	0.44	0.39	0.40	0.41	0.42	0.43	0.45
		30%	0.34	0.35	0.36	0.37	0.38	0.39	0.33	0.34	0.35	0.36	0.37	0.38	0.43	0.44	0.46	0.47	0.48	0.50	0.44	0.45	0.46	0.48	0.49	0.51
		40%	0.40	0.41	0.42	0.43	0.44	0.45	0.38	0.39	0.40	0.41	0.43	0.44	0.50	0.51	0.53	0.54	0.56	0.58	0.51	0.52	0.54	0.55	0.57	0.58
		50%	0.47	0.48	0.50	0.51	0.52	0.54	0.45	0.46	0.48	0.49	0.50	0.52	0.60	0.61	0.63	0.65	0.67	0.69	0.60	0.62	0.64	0.66	0.68	0.70

Source: Own elaboration

CONCLUSION

The NR 482 created an essential regulatory framework for micro and minigeneration projects. The current possibility to inject the excess of energy on the grid should favour those interested in producing their own energy.

The state-owned bank Caixa enabled Construcard credit loan modality for PV equipment at the end of 2014. That modality has provided the best results amongst the capital structures scenarios for the cities analysed, because of the appealing interest rates. Despite Construcard's lower rate benefits, its positive outcomes mostly happen under combined high tariff readjustments and aggressive initial cost reduction.

The low number of positive results under realistic assumption calls into question whether the current incentives are enough for a broad dissemination of small scale PV systems in Brazil. The results show that only a combination of high solar irradiation, high energy tariff, and low project discount rates turn the project into a financially viable investment.

A class B1 consumer with 500 kWh monthly average consumption is a proxy for high middle class household representation. Such consumer is wealthier than the average population, and usually has more access to financial services. The fact that the cities analysed are located at the richest part of the country is information that also should be highlighted. So, the hypothetic modelled consumer may not be realistic for the majority of the Brazilian population.

The reasonable variables subject to Government interference are initial cost reduction and credit loan rates specific to PV equipment. We might conclude that, if the Government wishes to encourage and increase the participation of such energy generation technology in Brazil, it should develop better financing mechanisms.

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