ARTICLE IN PRESS

Energy Policy ∎ (∎∎∎∎) ∎∎∎–∎∎∎

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Communication

Distributed photovoltaic generation in Brazil: An economic viability analysis of small-scale photovoltaic systems in the residential and commercial sectors

Claudius Holdermann*, Johannes Kissel, Jürgen Beigel

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Av. Nilo Peçanha, 50, Sala 3009, Ed. Rodolpho de Paoli, Centro, Rio de Janeiro CEP 20020-906, Brazil

HIGHLIGHTS

- We calculate the economic viability of photovoltaics in the residential and commercial sectors in Brazil.
- The PV*Sol simulations are carried out at the headquarter locations for the 63 distribution companies.
- Currently in none of the distribution networks, photovoltaics is economically viable in either the commercial or residential sectors.
- We analyze how the variation of the specific investment costs and of the discount rate affects the economic viability.

ARTICLE INFO

Article history:
Received 14 October 2013
Received in revised form
21 November 2013
Accepted 25 November 2013

Keywords:
Photovoltaics
Net metering
Brazil

ABSTRACT

This paper examines the economic viability of small-scale, grid-connected photovoltaics in the Brazilian residential and commercial sectors after the introduction of the net metering regulation in April 2012. This study uses the discounted cash flow method to calculate the specific investment costs that are necessary for photovoltaic systems to be economically viable for each of the 63 distribution networks in Brazil. We compare these values to the system costs that are estimated in the comprehensive study on photovoltaics that was developed by the Brazilian Association of Electric and Electronic Industries (ABINEE). In our calculation, we utilize the current electricity tariffs, including fees and taxes, which we obtained through telephone interviews and publicly available information. We obtained a second important parameter by simulating PV-systems with the program PV*Sol at the distribution company headquarters' locations. In our base case scenario that reflects the current situation, in none of the distribution networks photovoltaics is economically viable in either the commercial or residential sectors. We improved the environment for grid-connected photovoltaics in our scenarios by assuming both lower PV-system costs and a lower discount rate to determine the effect on photovoltaics viability.

© 2013 Elsevier Ltd. All rights reserved.

1. Introduction

Grid-connected photovoltaics, with an installed capacity of only 4.5 MWp, is still an underrepresented energy form in Brazil, considering the country's advantageous solar irradiation conditions (up to 2400 kW h/m²). The use of photovoltaics in Brazil has, until recently, encompassed mainly small-scale isolated systems in areas without connection to the national transmission network (SIN). In April 2012, the National Regulatory Agency for Electricity (ANEEL) introduced a net metering mechanism that applies to small-scale power plants supplied by renewable energies.

Several studies had already announced the possible economic viability of PV systems in the Brazilian residential sector before the introduction of the net metering regulation (ABINEE, 2012; EPE, 2012; Jannuzzi and de Melo, 2012; Mitscher and Rüther, 2012). The main objective of this study is to identify which of the 63 distribution networks possesses the potential economic viability of PV systems for both the Brazilian residential and commercial sectors following the introduction of the net metering regulation.

The larger portion of the value chain that has been privatized in the 1990s and the beginning of the 2000s is electricity commercialization, which is the area in which power purchase and sale activity is being conducted. The trade of electricity happens on two levels. Approximately 70% of all the electricity is traded in the ACR, the regulated trading environment, and approximately 30% is traded in the ACL, the free trading environment (Devienne Filho, 2011). In the ACR, the electricity is commercialized in public auctions to meet the

* Corresponding author. Tel.: +55 21 3550 6700.
E-mail address: claudiusholdermann@yahoo.com (C. Holdermann).

0301-4215/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.enpol.2013.11.064

Please cite this article as: Holdermann, C., et al., Distributed photovoltaic generation in Brazil: An economic viability analysis of small-scale photovoltaic systems in the residential and commercial sectors. Energy Policy (2013), http://dx.doi.org/10.1016/j.enpol.2013.11.064

electricity demand of the captive consumers – with the result that consumers cannot choose their supplier at their own discretion. The company that is willing to offer the tendered electricity amount at the lowest price wins the auction process (Kissel, 2008).

For this study the regulated trading environment is of central importance because the customer groups in the residential and commercial sectors are supplied within this category. The 63 distribution network operators in Brazil are natural monopolies in their supply areas, therefore, the electricity tariffs are determined by the regulatory agency ANEEL. The electricity tariff groups are classified by the supply voltage of the customers. Because the highest electricity tariffs exist in the low-voltage distribution network, we focus on the tariff groups supplied with <2.3 kV. The relevant tariff groups are B1 (residential) and B3 (commercial). These tariff groups account for approximately 80% of all the electricity consumption in the low-voltage distribution network. The residential and commercial sectors (supplied in the low-voltage distribution network) make up approximately 40% of the electricity consumption when the whole ACR is taken into account.

To facilitate the understanding of our approach, we introduce the net metering regulation (Resolução Normativa N° 482) that was published in its newest version in December 2012. This regulation is in accordance with the Brazilian energy policy that is composed of moderate electricity prices, secure electricity supply and universal access to electricity.

2. Net metering for distributed generation

In April 2012, the National Regulatory Agency for Electricity (ANEEL) introduced a net metering mechanism that applies to small-scale power plants that are supplied by renewable energies. The aim of the net metering mechanism is the removal of the barriers for distributed energy generation.

The net metering mechanism applies to small-scale power plants that are supplied by renewable energies up to a capacity of 1 MW. The mechanism is composed of micro-generation plants (≤ 100 kW) that are connected to the low-voltage distribution network. However, mini-generation plants (>100 kW and ≤ 1 MW), or systems that are linked to either the low- or the medium-voltage distribution network, are also components of the mechanism. The net metering is an incentive mechanism for renewable energy use and permits the consumer unit to subtract the self-produced energy from its measured consumption. In times of overproduction, the electrical energy is injected into the grid which serves as 'electricity storage'. When a consumer unit's electricity consumption is higher than the production, the consumer unit is allowed to use the electricity supplied by the grid. The produced and injected energy is subtracted from the amount of electricity consumed from the grid in the form of electricity credits (in kW h), not monetary units. If the production of energy is higher than the consumption during the accounting period, the overproduction is credited to the next month. The credits are valid for 36 months. In the case of higher consumption than self-production, the negative balance has to be paid by the consumer unit in the form of the prevailing electricity tariff. The monthly electricity bill provides the consumer unit with the balance information. The consumer is able to compensate for a negative future balance by overproduction in the present. Moreover, it is allowed to unite several consumer units if they are registered under the same taxpayer identification number (CPF), or with the same corporate taxpayers registration number in the case of companies (CNPJ) (ANEEL, 2012).

3. Methodology

Our objective is to determine if photovoltaic systems are economically viable in the Brazilian residential and commercial sectors in the 63 Brazilian distribution systems under prevailing and changing circumstances. Grid parity is reached when the levelized cost of electricity (LCOE) equals the end consumer tariff of the distribution network operator (Bhandari and Stadler, 2009). Grid parity describes the situation when the potential investor is indifferent between investing in a photovoltaic system and being continuously supplied by electricity from the grid.

We assume two representative consumptions for the Brazilian residential sector of 4.8 MW h/yr and of 48 MW h/yr for the commercial sector when connected to the low-voltage grid. With PV*Sol[1] – a PV-system simulation software – we simulate the size of the PV system that the consumer unit uses for electrical self-sufficiency at sites where the headquarters of the distribution networks are located because of reasons of simplification (the result is that the locations with the best solar irradiation are not necessarily being used). Depending on the specific annual yield at the different locations, the size of the photovoltaic system can be bigger or smaller. At locations with higher irradiation levels, the consumer unit requires a smaller PV system than at locations with lower irradiation levels.

We use the following revenue and cost structure (inflow and outflow) of the representative PV system (Table 1).

$$K_0 = -I_0 + \sum_{t=1}^{n} \frac{(1-t\alpha)G_1(1+\beta)^t T_1 - OM_t}{(1+i)^t} + \frac{L}{(1+i)^n} \quad (1)$$

According to the Brazilian net metering regulation, no revenues exist through the injection of generated electricity to the grid. However, the consumer unit does save the money it would otherwise spend on electricity from the grid. We consider this unspent money to be revenues of the PV system – inflows. We assume a system lifetime of $n=20$ because most module manufacturers guarantee the modules for at least this time span.

The PV system produces $(1-t\alpha)G_1$ units of electricity. G_1 is the electricity production in the first year of operation. $(1-t\alpha)$ accounts for the constant annual efficiency decrease of the PV system in relation to the initial production (Mitscher and Rüther, 2012). $(1+\beta)^t T_1$ consists of the electricity tariff T_1 in the first year of operation and its change $(1+\beta)^t$ in relation to the previous year. Bonini (2011) identified an exponential growth for the years 2003–2010 (*residential and commercial sector*). OM_t are the operation and maintenance costs, an annually constant value that we define as $OM_t=\gamma I_0$ and represents the share of the initial investment. γ is a constant factor. The term $(1+i)^t$ is used to discount the cash inflow and outflow. The value for i is defined by the minimum acceptable rate of return (MARR) for an investor. It is composed of the return of a financial product with an equivalent risk, such as the PV investment. L is the liquidation proceeds and it is a part of capital budgeting. We neglect it in the calculation and assume that dismantling costs and scrapping proceeds are equal to zero (ARGE Monitoring PV-Anlagen, 2007; Kost et al., 2012).

The photovoltaics in Brazil is still at the initial stages of market development and detailed cost information is either not available or inconsistent. Therefore, the approach in this study is to determine the level at which photovoltaics in Brazil can be economically viable (in €/kWp), not the effective cost.

To do this, we assume $K_0=0$. By transformation, we isolate I_0 and obtain the following term:

$$I_0 = \frac{\sum_{t=1}^{n}(1-t\alpha)G_1(1+\beta)^t T_1/(1+i)^t}{1+\gamma\sum_{t=1}^{n} 1/(1+i)^t} \quad (2)$$

To calculate the 63 values for I_0, we use the parameters in Table 2 and the solar irradiation data in the distribution networks. Moreover, we use the distinct electricity tariffs that are unique in

[1] Dr. Valentin EnergieSoftware GmbH 2012.

Please cite this article as: Holdermann, C., et al., Distributed photovoltaic generation in Brazil: An economic viability analysis of small-scale photovoltaic systems in the residential and commercial sectors. Energy Policy (2013), http://dx.doi.org/10.1016/j.enpol.2013.11.064

Download English Version:

https://daneshyari.com/en/article/7402622

Download Persian Version:

https://daneshyari.com/article/7402622

Daneshyari.com