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Deployment of photovoltaics in Brazil: Scenarios, perspectives and policies for low-income housing

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Abstract

Solar irradiation in Brazil is favorable for electricity generation, yet this energy source represents less than 0.1% of the Brazilian energy matrix. This article presents photovoltaic solar panels as an important alternative in the context of the Brazilian energy crisis. Solar irradiations levels were considered to calculate the number of solar panels necessary to supply the average electricity demand of social housing programs. A scenario approach and an OFAT sensitivity analysis were used to evaluate feasibility (IRR, NPV, cash flow and payback) based on existing electricity charging policies and usual long-term financing plans for social housing programs. The results for all the proposed scenarios indicate that photovoltaics are an environmentally and economically feasible alternative. Deploying between four to seven 217 W photovoltaic panels onto each house would meet the needs of all solar irradiation zones considered, making dwellers significantly less dependent on the grid and capable of up to 47% grid feedback for up to 30 years. Finally, feed-in tariff policies and a trust fund for maintenance and reinvestment costs are suggested in order to stimulate the use of photovoltaics as a sustainable alternative.

Keywords: Energy policy; BIPV; Photovoltaics; Feed-in tariff

1. Introduction

The increasing demand for energy, resulting from increasing socio-economic activities around the world, must be considered in terms of efficiency, reliability and environmental aspects. In this context, renewable energy alternatives have become the focus of many studies addressing environmental and economic issues. Some countries are on the cutting edge of technological and regulatory investments in cleaner energy generation, enabling countries that have just recently begun to take alternative energy sources into consideration to learn from their experiences (Razykov et al., 2011; Saidur et al., 2011; Moosavian et al., 2013; Enteria et al., 2014).

Solar power has great potential to contribute to many of the social and environmental aspects of growing electricity demands (Razykov et al., 2011; Mahesh and Jasmin, 2013;

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Cicea et al., 2014; Enteria et al., 2014). In addition to low carbon emissions, solar energy requires no fossil fuel input and can present favorable payback time if deployed under adequate irradiation conditions and considering the relevant and applicable economic parameters. When analyzing international solar energy policies and projects, several opportunities are notable for adaptation and deployment to stimulate the use of this technology in Brazil (Leite, 2007; Ordenes et al., 2007; Rüther et al., 2008a; Razykov et al., 2011; Pao and Fu, 2013a; Aman et al., 2015).

Brazil is a developing country located in tropical and subtropical climatic regions, in which the intensity of sunlight radiation and several economic variables favor the use of solar technologies (Ordenes et al., 2007; MME, 2011; Rüther and Naspolini, 2011; ANEEL, 2014; Pao and Fu, 2013a; Reuters, 2014; Mohammed et al., 2014; EPE, 2014).

The Brazilian energy matrix consists mostly of hydraulic and natural gas sources, both of which require large investments and, often, more than five years to be fully operational. (Aldabó, 2002; Martins et al., 2008a,b, 2012; Rüther et al., 2011; ANEEL, 2014; MME, 2015). However, throughout the last 20 years, this heavy reliance on hydraulic energy – hindered by low precipitation during usually rain-intensive seasons – and on natural gas – with supplies directly affected by political and diplomatic instability – has not been seriously questioned (Knox-Hayes et al., 2013; Pereira et al., 2011, 2013; Pereira et al., 2012; Pao and Fu, 2013a,b; Sthel et al., 2013; Guerra et al., 2015; Camioto et al., 2014).

Considering the estimated annual growth in Brazilian electricity consumption of up to 4.2% until 2023 (MME, 2012; ANEEL, 2014; EPE, 2013), and despite the recent US$ 1.1 billion invested by the government, the country faces an energy crisis that could have been averted if earlier investments and policies had been made towards fostering renewable energy sources (Palz, 1995; Hinrichs and Kleinbach, 2004; Jochem et al., 2005; Leite, 2007; Martins et al., 2008b; MME, 2010; Rüther et al., 2008a, 2010, 2011; Pereira et al., 2012).

As shown in Fig. 1, solar irradiations considered good for electricity generation (above 4 kW h/m^2 per day) cover over 90% of Brazilian territory, however, installed capacity today is just 15 MW h (Patel, 1999; Sen, 2004; Martins et al., 2007; Mubiru and Banda, 2008; Janjai et al., 2009; Behrang et al., 2010; Janjai, 2010; MME, 2012, 2015; ANEEL, 2014; EPE, 2014). Further arguing in favor of the deployment of solar power based alternatives are the Brazilian Energetic Research Company (EPE) and the Brazilian National Institute for Space Research (INPE), which demonstrated that (a) Brazilian solar power potential exceeds approximately 230% of its current electricity consumption, and that (b) the deployment costs of photovoltaic solutions tends to annually decrease in the range of 3.3–6.5% until 2030 (EPE, 2013, 2014).

In comparison to Germany – a country in which solar irradiation is considerably less favorable yet electricity generation from solar power is almost five times higher (AGEB, 2015; BGR, 2015; EPE, 2013, 2014), and when analyzing Brazil's difficulties in making use of this technology, the main issue becomes clear: lack of policies and programs that stimulate photovoltaic deployment and that contribute to the creation of a more competitive market for both manufacturers and retailers (Bodach and Hamhaber, 2010; Silva et al., 2010; Ruiz-Arias et al., 2015; Saidur et al., 2011; Rüther and Zilles, 2011; Echegaray, 2014; Moosavian et al., 2013).

In the last ten years, few new energy policies or programs have been created in Brazil; most of those implemented are focused on biodiesel (e.g., National Alternative Energy Stimuli Program (PROINFA) and the National Biodiesel Production Program (PNPB)) and ethanol (e.g., National Ethanol Agricultural Zoning Program (ZAECANA)). Alongside the aforementioned examples, the State and Municipal Energy Development Program (PRODEEM), which encompasses solar and wind sources and compensates/rewards companies that deploy clean energy in their production systems, is seen by the market as bureaucratic, superficial and unwelcoming to the deployment of new technologies (Aldabó, 2002; Leite, 2007; MME, 2011; Rovere et al., 2011; ANEEL, 2014; Padula et al., 2012; Castanheira et al., 2014).

From a regulatory perspective, the Brazilian National Electric Energy Agency (ANEEL) has brought into force legislation that encompasses solar energy, such as Resolution N°77/2004 – that reduces transmission and distribution fees up to 80% until 2017 and to 50% after 2017 for renewable electricity generation enterprises – and Resolution N°482/2012 – that defines the kW h ranges for micro- and mini-generation systems as well as establishes the compensation system for individuals or companies to abate their electricity bill based on energy fed back to the grid. The latter also sets the criteria and parameters for the measurement, calculation and operation of the compensation system, however limiting the use of grid feedback credits to 36 months without cross-discount possibilities (ANEEL, 2004, 2012a,b,c).

These regulatory initiatives from ANEEL, however, do not configure policies or programs such as those seen in the United States, the Netherlands, the United Kingdom, Canada, Germany, Spain, Australia, China, India, Malaysia and France, for example. These nations have robust and comprehensive policies that tackle solar energy from all angles, including the regulatory (e.g. tax exemptions, subsidies, feed-in tariffs (FIT), cross-discounts), without ignoring the need for investment incentives, technological research and development stimuli, renewable energy education and operational standards for building-integrated photovoltaics (BIPV).

Since these countries have begun making solar energy available to more residential consumers while establishing a holistic solar energy market support structure, significant results have been achieved: by 2016, the overall average growth of this energy source is expected to be 30% higher than in 2008 (Patel, 1999; Sen, 2004; Costa et al., 2008;