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Stakeholder subjectivities regarding barriers and drivers to the introduction of utility-scale solar photovoltaic power in Brazil

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ABSTRACT

Barriers and drivers of renewable energy systems are contingent upon particular technologies, social organizations, and institutions. Identification of barriers and drivers is necessary to devise policies and strategies to facilitate the introduction and dissemination of renewable energy generation. In 2002 the Brazilian government encouraged the adoption of renewable energy technologies such as wind, biomass and small hydroelectricity. Beginning in 2014, Brazil's federal regulatory agency started auctions aiming to develop ~12 GWp of utility-scale solar photovoltaic (PV). This paper explores the barriers and drivers to introduction of the solar photovoltaic technology in Brazil by focusing on the analysis of empirically determined subjectivities among the electricity power sector actors in the case of the Minas Gerais state. We identify and describe three perspectives (factors) using Q-method: (1) "We can do it" (2) "Step-by-step"; and (3) "It's not the money." Within these perspectives, planning for siting power plants, lack of transmission network, and biodiversity impacts were identified as three main statistically significant and highly ranked barriers. Identification of social perspectives may avoid conflict barriers to introducing utility-scale PV and suggest socially acceptable solutions for technical and economic issues.

1. Introduction

Implementing renewable energy technologies (RETs) is a policy priority in many countries, but governments face many complex barriers in making RETs viable technically and efficient economically. The gap between potential and actual RET conversion is partly the result of technical and economic barriers to deployment resources (Eleftheriadis and Anagnostopoulou, 2015; Reddy and Painuly, 2004). One optimistic view is that only "social and political" barriers impede the move toward complete global reliance on wind, water, and solar power by 2050 (Jacobson and Delucchi, 2011).

Several factors are responsible to creating barriers to RET expansion. One group of scholars has indicated the need for a technical-institutional paradigm change in the traditional power sector because RET demands structural, social, organizational, and economic changes (Wolsink, 2013, 2012; Tsoutsos and Stamboulis, 2005). For example, Wustenhagen et al. (2007), p. 2685) argue that power-generating firms "influence public policies and the ability of firms seeking to enter the power sector to access distribution infrastructure." Wolsink (2012) reports strong resistance to change firm behavior regarding penetration in the electricity sector. Del Rio and Unruh (2007, p. 1499) attest that "pre-existing infrastructure, both physical and institutional, can create important constraints on the adoption patterns of new technologies." For Brazilian utility-scale photovoltaic (PV), scientists report that low auction prices and weak government subsidies are barriers (Corrêa da Silva et al., 2016; de Jong et al., 2015; Souza and Cavalcante, 2016). Other reports indicate strong future growth in Brazilian solar (IEA, 2016) and highlight challenges regarding transmission capacity (REN21, 2015)

The challenge of reducing technical and economic barriers has attracted the attention of entrepreneurs, scientists and politicians around the world (Pinto et al., 2016; Echegaray, 2014; Matos and Silvestre, 2013). However, policy makers tend to offer solutions that do not apply to attending environmental, social, organizational, and political problems (Pereira et al., 2013; Zoellner et al., 2008). As a consequence, introduction of RETs is delayed in favor of maintaining traditional energy conversion technologies (Wolsink, 2013, 2012). Detailed empirical findings about social perspectives among power-sector stakeholders offer the opportunity for policy recommendations aimed at overcoming barriers and maximizing PV dissemination (Sindhu et al., 2016).

Here we determine subjectivities in the Brazilian power sector

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among entrepreneurs and officials in power regulation, generation, distribution and transmission regarding barriers and drivers for utility-scale PV. Identifying subjectivities or social perspectives may improve knowledge of barriers to photovoltaic introduction and help identify specific rationales influencing stakeholders and their ability to articulate favorable attitudes toward PV introduction and diffusion in Brazil.

2. Background

2.1. Barriers to RET expansion

The literature identifies several specific barriers to RET expansion. The existing electricity distribution network is cited as a barrier by several authors, who emphasize conflicts of interest and market power as slowing RETs (Wolsink, 2013, 2012; Jacobsson and Bergek, 2004; Unruh, 2002). For example, Wolsink (2012), p. 1811) argues that pressure exerted by incumbent firms "try to use their influence in the crucial political decisions" about system design, grid access, and RET incentives.

Workforce and information are also key barriers to RETs (del Río and Unruh, 2007). Unruh (2000) emphasizes the need to train technicians and professionals capable of supporting technological introduction and diffusion. Solar insolation maps are a key aspect of information availability needed to attract PV firms. As Martins and Pereira (2011), p. 4388) argue, "global investors may not know about the existence of viable solar sites.".

Incentives and cost barriers are cited by many authors, such as Martins and Pereira (2011), p. 4388), who argue that RET "incentive programs must be devised at municipal, state and federal levels." For these authors, defining a reference value for the price of solar and wind energies allied with tax reductions and exemptions on equipment and profits of companies operating on these renewable technologies were especially important. Persistence of negative incentives, such as subsidies directed to traditional power technologies, is another problem that may delay innovations (Zhai and Williams, 2012; Jacobsson and Bergek, 2004). Many authors agree on the need for governments to offer better purchase prices for solar power (Martins and Pereira, 2011; Goldemberg and Coelho, 2002) and other subsidies to offset the relatively high price of PV power (Corrêa da Silva et al., 2016; de Jong et al., 2015; Souza and Cavalcante, 2016).

Planning and siting procedures "influence payback time or delay government subsidies that may be available to investors" (Frate, 2015, p. 2), but Wustenhagen et al. (2007), p. 236) note that "traditional power-generating sectors may not have the institutional culture of planning and siting", which is a barrier to implementing RET. Montezano (2012) argues that regional scale studies for siting PV are important because of the relatively small area of proposed RET projects and relatively high cost of individual siting studies.

Land requirements, which are relatively high owing to low power densities of PV (Smil, 2015), represent another barrier. Large land purchases may be expensive (Shah et al., 2015). Attachment to place may help generate conflicts over land; Wolsink (2012) noted that land is not only the site of the conflict, but also the origin of the conflict. In coastal Brazil, land-tenure insecurity is a key reason for wind power conflicts (Brannstrom et al., 2017). Concerns over biodiversity impacts are closely related to the land issue, as demonstrated by conflicts in California solar power development (Storms et al., 2013). Biodiversity impacts include landscape fragmentation (Nunes and Meyer, 2014; Tsoutsos et al., 2005) and soil disturbance (Hernandez et al., 2014). Fthenakis and Zweibel (2003) show that PV power plants require water at volumes of 0.02 m^3/MWh for cleaning.

2.2. Brazilian RET policies

Brazilian electricity generation is composed mainly of hydroelectricity (64%), thermal (natural gas, coal, biomass and nuclear; 33%), while solar PV accounts for 0.2% (MME, 2016). High reliance on hydropower generation helped produce social movements opposed to social and environmental impacts of large dams in the Amazon region (Pereira et al., 2013; Farias, 2014; Rothman, 2001; McCormick, 2007); in addition, severe drought in 2001 sharply increased electricity prices, creating major political difficulties and putting economic development targets beyond reach. Pinto et al. (2016) attest that throughout the last 20 years, the heavy reliance on hydropower has not been seriously questioned, but since 2002 the Brazilian government has expanded and diversified its energy portfolio focusing on techno-institutional developments, research-development projects and public policies. Juarez et al. (2014), p. 833), describe the insertion of RET into Brazil's grid as "a win-win situation for society, energy firms and the environment" while Ribeiro et al. (2016), p. 554) point out that RET "is viewed by society as a positive alternative to support economic and social development". Goldemberg and Coelho (2002), p. 55) even argue that RETs can "help Brazil reduce poverty and inequality."

Utility-scale PV in Brazil is comprised of 44 plants in operation (28 MW potential) and 21 plants under construction (616 MW), with 90 plants (2.4 GW) in planning stages (ANEEL, 2017). Observers predict that PV will play an important role in the future, from 0.5 GW (0.2%) in 2017–3.5 GW (1.8%) in 2023, likely to exceed biomass and small hydro power (Empresa de Pesquisa Energética (EPE), 2014a). Growth of PV was stimulated by Brazil's Ministry of Energy and Mines (MME), which held an auction in 2014 dedicated to the purchase of energy produced by PV. This auction received bids of 10.79 GW (400 projects), of which 0.89 MW were contracted (3 projects) at mean price of R$ 215 per MWh (~US$72 in early 2015 and ~US$54 in early 2016), nearly 18% less than the opening price. The investment for 0.89 GW is approximately R$ 4.14 billion (~US$1.38 billion and US$1 billion in early 2015 and early 2016, respectively) to R$ 4.7 million per MW (~US $1.57 billion and US$1.18 billion in early 2015 and early 2016, respectively). A second auction took place 14 August 2015 with the expectation that 1.27 GW (36 utility-scale projects) will be contracted for Minas Gerais state (Empresa de Pesquisa Energética (EPE), 2014b).

PV has high public acceptance in Brazil because it is associated with a permanent energy source and is not known to cause negative socio-environmental impacts. This idea is produced mainly by government and international development agencies, universities and power plant entrepreneurs (Carneiro, 2000; Locatelli, 2011; Farias, 2014), which seek Brazilian media outlets as means to legitimize their sustainability discourses to create and expand their participation in energy markets. As a consequence the media portray the idea that rapid diffusion of RETs is essential and desirable in comparison to hydroelectric power, which has created strong social opposition (Rothman, 2001; McCormick, 2007; Locatelli, 2011) while generating less power because of low reservoir levels.

Governance of Brazil's electricity sector is dominated by state-run firms and private firms that bid on electricity supply auctions. These groups are relatively insulated politically from universities and social organizations. Identification of different views or social perspectives among representatives of the electricity sector may create a more holistic understanding of barriers and drivers regarding a specific RET, which is seen almost exclusively in highly positive and non-problematic terms.

However, the literature on Brazilian solar power does not yet describe stakeholder perceptions and discourses about utility-scale PV. This is an important gap in knowledge because the addition of new hydropower capacity is highly problematic on grounds of efficiency and environmental costs (Corrêa da Silva et al., 2016), while new coal and nuclear power plants are not justified economically or environmentally (de Jong et al., 2015). Studies aimed to discuss social perspectives in the Brazilian's electricity sector are necessary to determine empirically diverse stakeholders' views on barriers to maximize drivers to PV dissemination and diffusion (del Río and Unruh, 2007). Scholars have indicated that "government incentives" and a "favorable business