Journal of Cleaner Production 123 (2016) 124–136

Contents lists available at ScienceDirect

Journal of Cleaner Production

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

Overcoming barriers to renewable energy diffusion: business models for customer-sited solar photovoltaics in Japan, Germany and the United States

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ARTICLE INFO

Article history:
Received 1 February 2015
Received in revised form
7 June 2015
Accepted 25 June 2015
Available online 2 July 2015

Keywords:
Photovoltaics
Deployment
Business model
Barriers

ABSTRACT

Transformative change of energy systems towards distributed renewable technologies requires not only technological but also organisational innovation in order to engage broad segments of the private consumer market. Using the business model concept as an analytical tool, this comparative study investigates organisational configurations related to the deployment of customer-sited photovoltaic (PV) systems in Germany, Japan and the United States. Results show how the deployment of customer-sited PV systems in these three countries has been enabled and catalysed through distinctively different business models. Specifically, solar firms have managed to overcome various barriers to the adoption of PV in distinct ways. Furthermore, we identify a number of contextual conditions that have shaped the design and mode of operation of the respective business models in the three countries. The study provides novel insights for both policy makers and solar firms that wish to develop alternative governance models and new business strategies, respectively. Such insights are important to support the accelerated diffusion of distributed PV systems.

1. Introduction

Addressing the multiple challenges of global sustainability, energy security and socio-economic development will require transformative change of energy systems towards a broad portfolio of low-carbon technologies (GEA, 2012). Among these technologies, photovoltaics (PV) is unique as it allows homeowners to produce and self-consume electricity at even small capacity ratings, with minimal maintenance and no fuel costs. PV is considered a radical architectural innovation (Awerbuch, 2000) that is potentially disruptive to the established modes of electricity generation and delivery (Schleicher-Tappeser, 2012), and that can enable new forms of value creation that emerge in existing as well as new organisational configurations.

Despite the potential to become a significant source of low-carbon electricity (Arvizu et al., 2011), the literature has identified a number of key barriers to the market adoption of PV. These barriers include consumer inertia, high up-front cost, long payback periods, efforts associated with the planning and installation steps, various informational gaps and customer concerns about PV reliability (Rosoff and Sinclair, 2009; Shih and Chou, 2011; Yang, 2010). Moreover, motivations and personal priorities differ across consumer groups and depend on consumer personality and behaviour, values and attitudes, age, etc. (Balcombe et al., 2013, 2014; Leenheer et al., 2011). For example, early adopters are more prone to take up the risks, complexities and lack of short-term benefits of radical innovations such as PV than average mainstream consumers (Moore, 1999). Mobilising mainstream consumer groups to engage in PV requires convincing in terms of affordability, visual attractiveness, low maintenance, provision of added value to the property and a simple installation process (Faiers and Neame, 2006). In order to address the various barriers, Schleicher-Tappeser (2012) argues that the mass adoption of distributed PV, from a consumer perspective, needs to be low-risk, include well-defined options, and rely on well-known models that are rolled out through “solution providers” to structure the large number of situations and opportunities into standardised and fast-to-implement solutions.

Previous research has explored the concept of the *business model* as a framework for analysing and operationalising sustainable innovations in general (Boons and Lüdeke-Freund, 2013) and

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http://dx.doi.org/10.1016/j.jclepro.2015.06.120
0959-6526/

PV deployment in particular, including PV business model innovation from a utility sector perspective (Frantzis et al., 2008; Schoettl and Lehmann-Ortega, 2011; Richter, 2012) and delivery models for rural electrification (e.g. Lemaire, 2011; Northrop et al., 1996; Rogers, 1999). Regarding the challenges of convincing mainstream consumers to adopt a PV system, a business model perspective can give new insights on how businesses focus in their value proposition on the customer problem that their product can solve. This can, for instance, be by highlighting the private benefit on top of the public benefit (Wüstenhagen and Boehnke, 2008). The few empirical studies that do exist and deal with this issue have often focused on selected elements of the business model concept only (see e.g. Drury et al., 2012; Huijben and Verbong, 2013; Överholm, 2013; Rai and Sigrin, 2013). Previous research has neither addressed the question of how real-life PV business models evolve in response to the opportunities and constraints present in their sociopolitical context, such as of a country, nor whether the same business model will work equally well in different contexts.

As a first step towards conceptualising the workings of a business model in different national settings, the objective of this paper is to compare the distinctively different organisational configurations for residential PV deployment in three large markets. Using the business model concept as an analytical tool, we analyse the deployment of customer-sited PV systems in Germany, Japan and the US. In Germany, local craft firms that were able to thrive on a national uniform system of feed-in tariffs and low-interest loans dominate PV deployment. In the US, solar service firms have grown rapidly by means of third-party ownership and leasing models. In Japan, cross-selling of PV systems in connection with other products and services is widespread, and the building industry in particular has taken a leading role by integrating PV systems into prefabricated homes.

The analysis offers novel insights as to how firms have managed to overcome many of the commonly observed barriers to PV adoption. Overcoming barriers has been central to creating consumer value and catalysing PV diffusion in the mainstream consumer segment. Furthermore, the comparative analysis provides a new perspective as to how these configurations are dependent on the national context in which they emerge. These insights are particularly valuable for policy makers who wish to leverage PV deployment through regulatory reforms that facilitate the uptake of distinct PV business models. The paper's findings regarding the dependence of business models on national contexts are also of interest to domestic solar entrepreneurs and to managers of multinational solar businesses who wish to expand into new markets.

The paper is structured as follows: In Section 2, we describe the theoretical background with regard to the business model concept. In Section 3, we outline the research design. In Section 4, we present the deployment of residential PV in Germany, Japan and the US, utilising a business model concept perspective. Here we also consider the embeddedness of the three analysed business models in the wider context of the respective countries. In Section 5, we compare and discuss the findings from our three cases in relation to the business model literature.

2. Theoretical perspective: business models and their contextual environment

In this section, we present a theoretical perspective on two aspects that are of particular relevance to the aim of this paper. Firstly, we discuss the role of business models as catalysts for the diffusion of sustainable innovations. Secondly, we emphasise that business models are embedded in a socio-technical context.

2.1. Business models as catalysts for market diffusion of sustainable innovations

Even though the underlying principles of business models have been integral to market economies and trade for millennia (Teece, 2010), the business model terminology and concept became prevalent in the mid-1990s with the emergence of the Internet (Zott et al., 2011). The concept builds on central ideas in business strategy (Morris et al., 2005), in particular on the value chain concept presented by Porter (1985). The business model concept also draws on resource-based theory, strategic network theory, cooperative strategies, transaction cost economics and industrial organisation strategy (Hedman and Kalling, 2003; Morris et al., 2005). While definitions, understanding and the terminology of the business model concept differ across groups of researchers and practitioners (Zott et al., 2011), the creation and capture of value are central in most business model definitions (Boehnke and Wüstenhagen, 2007; Shafer et al., 2005). Business models can serve as pivotal catalysts for the diffusion of new technologies by overcoming both internal and external barriers (Boons and Lüdeke-Freund, 2013), such as the reduction of customer transaction cost. Transaction cost economics identifies transaction efficiency as a major source of value, as the reduction of uncertainty, complexity, information asymmetry and small-numbers bargaining conditions fosters efficiency and reduces cost (Amit and Zott, 2001).

Specifically, the implementation of new business models has been identified as key for both the diffusion of sustainable innovations and for enabling a more sustainable use of existing technologies (Boons and Lüdeke-Freund, 2013). For example, successful business models for the marketing of clean technologies, such as product-service systems (PSS) (Bocken et al., 2014), focus in their communication on value by ensuring functionality, durability, reduced complexity and high responsibility of the provider. This reduces the number of tasks that customers have to perform, although offers can be adapted to the needs and capabilities of different customer groups (Reim et al., 2015). Besides, business models based on ownerless consumption can attract new customer segments, such as customers with lower financial capacity who may not have the financial resources to purchase a capital-intensive technology (Mont et al., 2006). In product-oriented PSS the provider still sells a product, but offers additional services such as maintenance, financing, extended warranties or advice and consultancy, thus lowering client barriers and reducing customer risks and uncertainties (Chattopadhyay and Rahman, 2008; Tukker, 2004). These additional services enhance customer value particularly for high-value and complex equipment with a long service life, such as PV systems.

2.2. Embeddedness of business models in their contextual environment

It is widely recognised that business models emerge or change in response to technological opportunities, institutional change and pressures in the business environment. Some authors explicitly recognise the role of national context for the emergence of new business models (Birkin et al., 2009; Budde Christensen et al., 2012) or even that characteristic business models emerge in response to the opportunities and gaps present in the institutional environment (Casper and Kettler, 2001). Particularly, politico-institutional and socio-institutional dynamics (Provance et al., 2011) such as changes in the law and changing consumer preferences (Linder and Cantrell, 2000) affect a firm's external business environment. In addition, disruptive and radical innovation (Johnson et al., 2008) and new technology paradigms (Johnson and Suskewicz, 2009) create new markets that are disruptive to customers and