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Evolution of photovoltaic business models: Overcoming the main barriers of distributed energy deployment

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ABSTRACT

The use of renewable energy resources is rapidly growing around the world. However, several barriers may hinder the diffusion of distributed energy solutions. This paper aims to identify the main inhibiting factors using a literature review methodology. To overcome these barriers and adapt to changing environmental conditions, companies operating in the distributed energy market need to develop innovative business model solutions. We therefore investigated the evolution of photovoltaic business models using the Business Model Canvas to determine how the obstacles to distributed energy deployment can be addressed. Finally, we applied the Lean Canvas to show the main differences between the models analysed and describe the benefits of the community-shared model compared with the alternatives, host-owned and third-party-owned solutions.

1. Introduction

The global solar photovoltaic (PV) industry has undergone a major transformation in recent years, with significant growth as a result of strong demand and the continual emergence of new markets [1]. However, according to estimates from GTM Research, global PV demand growth is expected to slow down in the next year and will reach 86 GW in 2018 [2]. This deceleration in major markets can be traced back to policy shifts and regulatory vagueness [3]. This paper therefore aims to examine the main barriers—including policy and regulatory aspects—that may influence the diffusion of renewable energy solutions.

Considerable changes have been seen in photovoltaic business models, as well as significant market growth. Changing contextual conditions have led to innovative concepts designed to tackle the increased complexity. Addressing the high upfront costs of solar systems and other emerging barriers, third-party-owned (TPO) and community-shared (CS) models have an increasingly important role. The TPO model offers Power Purchase Agreement and lease solutions, while CS models allow consumers to subscribe to a defined number of panels or a portion of the generated energy in solar parks through virtual net-metering. These solutions show that innovation is important in the PV market. Managers have a decisive role in successful business model adaptation and operation. They are advised to behave like entrepreneurs, be opportunity-driven and develop inventive products and services to address unmet customer needs and emerging inhibiting factors [4].

The United States is one of the leading countries for PV business model development, and several of its states continue to develop new renewable energy solutions. A good example is California, where the three biggest utilities (Pacific & Gas Electric, Southern California Edison, and San Diego Gas & Electric) were required to secure 600 MW of new community solar capacity by 2019 [5]. These attempts and business models could inspire countries that struggle with distributed energy (DE) deployment but are committed to renewables.

This paper uses a literature review methodology to evaluate the major barriers that may hinder the diffusion of distributed energy. We also identify and analyse the main PV business models using the Business Model Canvas (BMC), to give a full picture of the concepts and compare the identifiable models. Along the nine building blocks of the BMC, we highlight the value proposition and other core elements that distinguish each model and address consumers' problems, drawing on Osterwalder and Pigneur's [6] definition of business models.

TPO and CS models offer a possible solution for regions with a less developed residential solar market, so this review, and the detailed presentation of the core elements of the models, may help with adoption. We also use the Lean Canvas to identify significant consumer problems and possible solutions offered by the community-shared model, and provide examples of how and to what extent business models can provide solutions to the identified barriers. Finally, we give

Abbreviations: BMC, Business Model Canvas; CS, Community-shared; DE, Distributed energy; FiT, Feed-in tariff; kW_p, Kilowatt peak; LC, Lean Canvas; PPA, Power Purchase Agreement; PV, Photovoltaic(s); ROI, Return on Investment; RPS, Renewable Portfolio Standard; TPO, Third-party-owned

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a brief summary highlighting the value proposition of each model and some important implications for policy-makers, then note some future research issues. The paper's aim is to help policy-makers and business leaders to understand the problems that customers face in using renewables, and the main barriers to the spread of certain models, helping them to develop a proper political, regulatory and corporate background that will allow the widest possible dissemination of renewable energy resources.

The paper is organized as follows. Section 2 describes the theoretical background. Section 3 introduces the methodology and Section 4 the main barrier groups, while Section 5 sets out the business models. In Section 6, we synthesize the business models and in Section 7 we describe how the different business models can help overcome the identified barriers. The paper finishes with a summary and conclusions (Section 8) and some directions for future research in Section 9.

2. Theory

2.1. Business models

There is no commonly accepted definition of business model, and there are many approaches in the literature. The term itself was first introduced in economics in the 1950s, with an upswing in its use in the mid-1990s, with the emergence of Internet businesses. According to Zott, Amit and Massa [7], despite a significant increase in the number of publications on business model research, many researchers disagree on the meaning of the term.

Christensen and Johnson [8] described four compulsory elements of business models: *key resources*, including people, technology, products, tools and brand, *key processes* such as design, manufacturing and R&D, *value proposition for customers,* for instance, price and payment and finally the *profit form*, which includes the cost structure and the revenue model. Magretta [9], however, described the business model as nothing more than a story of how a company works. Overall, success depends on finding a good story. This referred back to Peter Drucker [10], who said that a good business model answers the questions “Who are the customers?”, “What is valuable to them?” and “How can this value be provided at an appropriate cost level?”.

Casadesus-Masanell and Ricard [11] stated that a business model is made up of decisions and consequences and defined three common features along which successful business models can be captured. Firstly, the business model must be in line with the company's goals. Secondly, the decisions made in the design of the model must complement each other: internal consistency is essential. Thirdly, a good business model should be able to overcome threats over time. Chesbrough and Rosenbloom [12] defined the functions of business models as articulation of value proposition, market segment identification, definition of the structure of the value chain, estimation of cost structure and profit potential, description of the position of the firm within the value network and formulation of a competitive strategy. Teece [13] emphasized that a business model includes identifying customer needs and payment capability, responding to these needs, and creating value for them. It also encourages customers to pay for the value provided, and converts these payments into profit by properly designing and operating the various elements of the value chain.

Chatterjee [14] suggested that the business model is about more than just making a profit by selling products and services. In his view, every business model starts with the value proposition, which is constantly evolving and so provides a competitive advantage for the organization. According to Osterwalder and Pigneur [6], *“a business model describes the rationale of how an organization creates, delivers and captures value”*. In this paper, we have used this definition as a starting point, because it fits well with renewable energy business models.

Business model innovation is also an important issue, because it enables companies to renew their value proposition, enhance their uniqueness, acquire new markets and customers, and gain long-term sustainable competitive advantage [15–20]. Bashir and Verma [19] suggested that business model innovation can serve as a sustainable competitive advantage, since imitating a whole new system is much more difficult than imitating a product or a service. Aspara et al. [21] defined business model innovation as *“initiatives to create novel value by challenging existing industry-specific business models, roles and relations in certain geographical market areas”*. Giesen et al. [22] identified three main ways to innovate business models: industry model, revenue model and enterprise model innovation. Some authors have differentiated between replication and renewal of business models. Replication refers, for example, to the exploitation of opportunities offered by an existing business model in other geographic areas [23], and renewal means introducing a new business model that goes beyond the previous one [24]. According to Amit and Zott [25], companies can implement business model innovation in a number of ways. These include the addition of new activities to business operations, the innovative linking of activities or changes in who performs the activity.

Several triggers of business model innovation have been identified, such as: (1) economic pressure [16,26,27], (2) product development-related issues [27], (3) price competition [18,19,27,28], (4) customer-related issues [27], (5) strategic circumstances [27,29], (6) underlying conditions [20], (7) situational triggers [20,30–32] and (8) increasing digitization [33–35].

2.2. The business model canvas

The Business Model Canvas provides an attractive template for visualizing new or existing business models. Osterwalder and Pigneur [6] divided the tool into four parts: customers, value proposition, infrastructure and financial aspects. The customer part covers customer relationships, customer segments and distribution channels. The value proposition includes those products and services that solve a specific problem and create value for the customers. The infrastructure section covers the architecture used for value creation, and the financial aspects highlight the connection between revenue streams and the company's cost structure.

Several articles and studies can be identified that have used the Business Model Canvas to demonstrate business models in the energy sector. Hannon et al. [36] used it to discuss the characteristics of Energy Service Companies and Energy Utility Companies. Richter [37] used its building blocks to compare utility-side and customer-side renewable energy business models. Huijben and Verbong [38] also applied the building blocks to describe the main types of PV business models in the Netherlands, as did Strupeit and Palm [39] in the United States, Japan and Germany. Meier [40] used the BMC framework to evaluate PV business models in emerging regions.

2.3. The Lean Canvas

The Lean Canvas (LC) is a business model hypothesis testing and validation tool that can be considered as a further development of the BMC [41]. It offers a more structured way to understand customer problems, and to build the value proposition and solution around them. It also highlights the main risks during the learning process. Its creator based the LC on the BMC but changed some fields to make it even more action-oriented.

One important addition was the Problem section. Many companies fail because they do not focus on real consumer demand, and waste time and money developing the wrong products and services. Another addition is the Solution, because once a firm understands the customers' problem, it is then in the best position to identify an appropriate solution. It is very important to measure the right elements of the operation, which can be recorded in the Key Metrics section. The fourth new part in the LC is a section on Unfair Advantage, which means obstacles preventing others entering the market.

The LC also removed some parts of the BMC, such as the Key