Solar business models from a firm perspective – an empirical study of the Swedish market

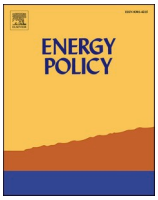
Citation for the original published paper (version of record):
Bankel, A., Johansson Mignon, I. (2022). Solar business models from a firm perspective – an empirical study of the Swedish market. Energy Policy, 166.
http://dx.doi.org/10.1016/j.enpol.2022.113013

Energy Policy 166 (2022) 113013

Contents lists available at ScienceDirect

Energy Policy

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



Solar business models from a firm perspective – an empirical study of the Swedish market

Amanda Bankel *, Ingrid Mignon

Department of Technology Management and Economics, Chalmers University of Technology, 412 96 Göteborg, Sweden

ARTICLE INFO

Keywords:
Business model
Solar photovoltaic
Sweden
Value
Provision
Sustainability transition

ABSTRACT

A worldwide transition towards sustainable energy systems requires the diffusion of renewable electricity technologies. To achieve this, recent research has put emphasis on the role of business models as catalysts for sustainability transitions, particularly in the case of solar photovoltaics. Authors have identified a variety of solar business models that can be characterized based on roles, activities, and applications. In contrast, on the market, solar firms use business models to communicate their offer to clients, focusing on customers' needs, how they organize their resources and activities to meet these needs and, in return, create value for themselves. The aim of this paper is to bridge the gap between the way energy policy literature describes solar business models, and the way solar firms use them to communicate with their clients. The business models of 241 solar firms in Sweden were mapped and analyzed using a framework developed by Richardson (2008) as well as the roles, activities, and applications as highlighted in solar business model literature. This led us to identify six types of solar business models. We found that there are some gaps and overlaps between theoretical and empirical solar business models which, in turn, have implications for theory and policy.

1. Introduction

In recent years, it has become clear that a worldwide transition towards more sustainable energy systems requires a large deployment of renewable electricity technologies (RETs), such as wind or solar photovoltaics (PV) (IEA, 2021). Such deployment cannot be carried out by governmental investments alone (Wüstenhagen and Menichetti, 2012). Instead, it is crucial that other types of investors, such as private firms, households, and associations, also participate in the diffusion of RETs (Bergek, Mignon et al., 2013). Previous studies on RET investors have shown that they represent a heterogeneous group of actors with different motivations, preferences, and resources (Palm and Tengvard, 2011; Mignon and Bergek, 2016). To attract these investors, market actors need to develop and broaden their offers to new and diverse market segments.

Lately, the business model (BM) concept has received increased attention in the literature exploring ways to accelerate a transition towards more sustainable energy systems (Burger and Luke, 2017). BMs have been found to serve as catalysts for sustainability transitions (e.g. Bolton and Hannon, 2016; Sarasini and Linder, 2018), especially for decentralized RETs, such as solar PV (e.g. Ford, Walton et al., 2017; Bidmon and Knab, 2018; Proka et al., 2018). Studies have shown that BMs have the potential to democratize access to RETs by facilitating adoption among different investor groups (e.g., communities, private households) (Huijben and Verbong, 2013). Yet, BMs are unlikely to drive major system changes unless they are supported by reforms in political, regulatory and market structures (Bolton and Hannon, 2016). Likewise, governmental support mechanisms, such as feed-in-tariffs and subsidy schemes, can have a large impact on the revenues and costs of solar PV projects, and thus greatly influence the success or failure of specific BMs (Burger and Luke, 2017; Karneyeva and Wüstenhagen, 2017). Given how much policies affect and can influence BMs, it is of crucial importance that policymakers better understand BMs (Bidmon and Knab, 2018).

When diving into the specific example of solar PV, it is clear that recent research has devoted particular attention to BMs used in the deployment of the technology (e.g. Schoettl and Lehmann-Ortega, 2011; Drury, Miller et al., 2012; Huijben et al., 2016; Strupeit and Palm, 2016; Tongsopit, Moungchareon et al., 2016; Burger and Luke, 2017; Horváth and Szabó, 2018). This has led authors to identify a variety of solar BMs that are characterized on different bases, including roles (i.e., who owns the solar PV system? Who uses the electricity?), activities (i.e., what

* Corresponding author.
E-mail address: amanda.bankel@chalmers.se (A. Bankel).

https://doi.org/10.1016/j.enpol.2022.113013
Received 17 November 2021; Received in revised form 25 April 2022; Accepted 27 April 2022
Available online 13 May 2022

services are performed in relation to solar PV systems?), and application (i.e., where is the solar PV system installed?). Examples of solar BMs discussed in the literature include host-owned, third-party ownership (TPO), community solar, turnkey, leasing, power purchase agreement (PPA), crowdfunding, savings-based, and revenue-based BMs.

Business models are used in this context to describe and understand the phenomenon of technology diffusion and acceptance, rather than to describe how a specific firm creates and captures value. Instead, many of these solar BMs resemble what Sauter and Watson (2007) refer to as deployment models, providing general pictures of the different roles, activities, and applications required for deploying solar PV. While this highlights important aspects that influence the way in which solar PV is deployed, we claim that the way these BMs are used and described in the literature does not mirror the logic used empirically by solar firms when designing or communicating around their BMs.

In contrast with what is described in the solar PV literature, on the market, solar firms use BMs to design and communicate their offer to clients, and these can look different depending on the firm. For instance, what the literature describes as a host-owned solar PV system can be provided by a solar firm as a complete solution that includes project development and installation, but it can also be sold as solar PV components where the customer is responsible for developing and installing the system. Firms with so-called host-owned BMs can thus have distinctly different offers and means of creating, delivering, and capturing value. Moreover, they also target differ types of investors (since clients buying solar PV components require different resources and skills compared to ones looking for a complete solution) and may react differently to policy influence. Hence, the theoretical host-owned BM does not reflect the variety of BMs used by solar firms that provide host-owned solar PV systems.

Against such background, turning to the general BM literature may be useful. In this literature stream, authors such as Teece (2010) have emphasized that a BM describes what benefit a firm delivers to its clients, how it organizes to do so, and how it captures a share of the value in return. While there is a growing consensus that such value is generated in a network and that several actors may be needed to realize a particular BM (e.g., Berglund and Sandström, 2013), scholar also agree that the BM concept remains centered around a focal firm from whose perspective the BM is described (Zott, Amit et al., 2011). As such, when value is generated in a network, the BMs of the involved actors will differ depending on whose perspective is taken since they may have different perceptions on e.g., who their customers are and what they offer these customers. Understanding solar BMs from the perspective of the firms that use them is, thus, crucial to understand the core of the dynamics, logics and transactions taking place between firms and their clients. For effective design and implementation of policy instruments intended to affect the solar PV market and its actors, such perspective cannot be overlooked.

Yet, many of the solar BM described in energy and energy policy literature either lack a clear focal firm perspective, or have been studied at an early stage of development and, hence, describe potential BMs rather than actual solar BMs in use (e.g., Schoettl and Lehmann-Ortega, 2011; Huijben and Verbong, 2013). With this paper, we want to bridge the gap between how the energy policy literature describes solar BMs, and how solar firms use BMs to communicate their offers to customers, organize their resources and activities, and create value for customers and themselves.

Drawing on the learnings of the solar PV- and BM literature, we map and analyze the BMs of 241 firms involved in sales, project development, and installation of solar PV in Sweden according to the value proposition, value creation and delivery system, and value capture (i.e., based on the framework by Richardson (2008)), as well as the roles, activities, and application as highlighted in solar BM literature. By combining these perspectives, we intend to clarify the connection between the way energy policy- and solar BM scholars understand and communicate around solar BMs and the way solar firms communicate around their BMs.

2. Theoretical framework

2.1. Solar business models

A variety of BMs used in the deployment of solar PV have been described and studied in previous solar PV- and policy literature. As presented below, these BMs are usually differentiated based on roles, activities, and applications.

2.1.1. Solar business models characterized by roles

In the solar PV literature, three types of solar BMs have received particular attention, namely the host-owned BM, TPO BM, and community solar BM. These are characterized based on who owns the solar PV system in relation to who owns the property where it is located and who consumes/sells the electricity that is produced.

The *host-owned BM* is based on the principle that the owner of the solar PV system is also the owner of the property on which the solar PV system is installed and the one selling or using its produced electricity (Horváth and Szabó, 2018). Such BM has historically been rather widespread and often received subsidies in the form of feed-in tariffs, investment subsidies or tax deductions (Huijben and Verbong, 2013; Huijben et al., 2016). One of the drawbacks described in the literature is that it requires customers (i.e. property owners) to make the investment upfront, which is often associated with a larger risk (Drury, Miller et al., 2012). In some cases, this model requires customers to handle challenges associated with e.g. choice of suppliers, technological features, and electricity sale contracts, despite a limited knowledge and experience in electricity production (Aspeteg and Mignon, 2019).

In the *TPO BM*, a third-party (i.e., not the property owner nor electricity consumer) owns and operates a solar PV system sited on a customer's roof, piece of land, or at a different location (Drury, Miller et al., 2012). Payments are captured either through *leasing*, where the customer uses the equipment to produce and use the electricity, or through a PPA, where the customer enters a long-term agreement to buy the produced electricity (Horváth and Szabó, 2018). The main advantage associated with this BM is that it is simple, it does not require customers to pay for the technology upfront, hence, relieving them from risk and responsibility related to the solar PV system (Drury, Miller et al., 2012; Överholm, 2015).

The *community solar BM* is based on shared ownership of the solar PV system among citizens forming a community. Members of these communities either consume some of the electricity themselves or sell it via a PPA or on the spot market. Community projects are often sited on local land or community buildings (Nolden, Barnes et al., 2020). The pros and cons of this BM is rather diverse depending on different projects and individual members participating in the projects (Mignon and Rüdinger, 2016). Previous studies have, however, stressed the large dependency towards economic incentive policies of this BM (Tongsopit, Moungchareon et al., 2016; Nolden, Barnes et al., 2020).

2.1.2. Solar business models characterized by activities

Apart from roles, authors have also highlighted that solar BMs vary significantly in terms of activities in relation to the solar PV value chain (e.g., Frantzis, Graham et al., 2008; Schoettl and Lehmann-Ortega, 2011) (Fig. 1). The solar PV value chain can be divided into an upstream and downstream part, where the upstream involves activities that rely on economies of scale (e.g., solar cell manufacturing and assembly) and the downstream is associated with activities of a more decentralized character (e.g., project development, installation, and maintenance) (Frantzis, Graham et al., 2008). Furthermore, the downstream value chain can be divided into one-shot and ongoing activities, where the former are carried out once for each solar PV system and the latter are repeated over the lifespan of each system (Schoettl and Lehmann-Ortega, 2011).

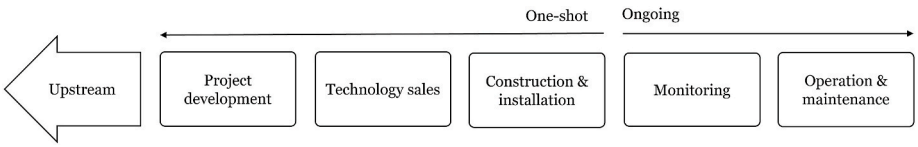


Fig. 1. Activities associated with the downstream solar PV value chain. Adapted from Schoettl and Lehmann-Ortega (2011) and Frantzis, Graham et al. (2008).

In their forward-looking study, Schoettl and Lehmann-Ortega (2011) identified a range of potential generic solar BM by considering the required firm competences related to these activities. They found that some firms will specialize on providing a particular service related to one activity in the value chain (e.g., consulting) while other firm with perform several activities as part of their BM. One such example is the turnkey BM that involves providing customers with a no hassle, plug-and-play solar PV system, a model that has later been identified in widespread use empirically as well (e.g., Altunay, Bergek et al., 2021).

2.1.3. Solar business models characterized by application

As a final categorization basis, some solar BMs have been differentiated based on their application. This refers to where the solar PV system is installed which, in turn, can be determined based on sector (e.g., residential or commercial), size (e.g., small- or large-scale systems), and location (e.g., roof- or ground-mounted) (e.g., Schoettl and Lehmann-Ortega, 2011; Burger and Luke, 2017; Lindahl, Berard et al., 2021). For instance, Burger and Luke (2017) distinguish between two solar BM archetypes both focusing on finance and installation that differ in terms of the size of application. They argue that the difference in system size influence the financing structures that are required by the BM, as large-scale solar firms often sell to multiple parties. Burger and Luke (2017) also highlight that it is often difficult to demarcate the size needed to classify within a specific application. In this paper we use the criteria presented in Table 1.

2.1.4. Overlaps among solar business models

In addition to solar BMs characterized on roles, activities, and application, studies also report many other solar BMs, including saving-based-, revenue-based-, merchant-, rental roof-, solar energy management service-, zero generation-, crowdfunding-, leasing-, and PPA BMs (Frantzis, Graham et al., 2008; Tongsopit, Moungchareon et al., 2016; Vasileiadou, Huijben et al., 2016; Zhang, 2016; Karneyeva and Wüstenhagen, 2017; Horváth and Szabó, 2018; Lindahl, Lingfors et al., 2022). While some of these focus on how to create businesses around solar electricity production rather than the BMs used in deployment of the technology (e.g., revenue-based and merchant BMs), others resemble the solar BMs differentiated based on roles and application but are viewed as distinct BMs. For instance, some authors consider leasing, PPA, and crowdfunding to be distinctly different solar BMs that provide customers with additional value beyond their financial structures, whereas others view them as versions of the TPO BM or community BM (e.g., Strupeit and Palm, 2016; Tongsopit, Moungchareon et al., 2016; Vasileiadou, Huijben et al., 2016; Burger and Luke, 2017).

As this review shows, there are clear overlaps between the solar BMs described in the literature. For instance, a turnkey BM can be applied to a host-owned BM or community solar BM, and a TPO BM can be viewed as a leasing BM or PPA BM. Likewise, as shown by e.g. Horváth and Szabó (2018), solar BMs with similar characteristics are labelled with different names, e.g., host-owned BM is also called customer-owned-, feed-in-, customer-sited-, or end-user owned BM, which adds further confusion when trying to navigate around the various types of solar BMs. As a consequence of these overlaps among solar BMs and the divergences in defining them, it is not very surprising that policymakers struggle to learn and understand the impact of policies on solar BMs (Bidmon and Knab, 2018).

This leads us to conclude that, although categorizing solar BMs based on roles, activities, and application highlights aspects that are both interesting and relevant for policymakers and energy scholars, it is not always clear whose BMs these are and how they create, deliver, and capture value for a particular firm. Instead, these BMs more often resemble descriptions of what Sauter and Watson (2007) refer to as *deployment models* that provide a holistic understanding of different ways in which solar PV can be deployed but lack the rationale of the different actors involved in such deployment. One way to bring clarity in the solar BMs, what they include and how they can be distinguished, is to go back to the core literature on BMs that emphasize the importance of viewing BMs with a focal firm in mind (e.g., Zott, Amit et al., 2011; Massa, Tucci et al., 2017).

Table 1
Solar PV system application. Adapted from Lindahl, Berard et al. (2021).

Sector	Size	Location
Residential	5-10 kW	Roof
Commercial	10-250 kW	Roof
Industrial	>250 kW	Roof
Utility	>1 MW	Ground

2.2. An entrepreneurship perspective on business models

The BM concept has been used intensively in the scientific entrepreneurship literature for the last twenty years. A reason for such interest is that the concept can be used for many things, such as understanding firm competitiveness and success, how to create and capture value from new technologies, and how to use it as a communication device to guide social action and persuade external stakeholders (e.g., Wirtz, Pistoia et al., 2016; Massa, Tucci et al., 2017).

Despite a myriad of definitions, a BM is often said to describe how a firm creates, delivers, and capture value (Osterwalder and Pigneur, 2010; Teece, 2010). This can be defined both at the organizational level or for each business unit and firms can have several BMs in parallel depending on the level of analysis that is taken (e.g. Casadesus-Masanell and Tarziján, 2012; Benson-Rea, Brodie et al., 2013). Scholars also acknowledge that BMs can transcend the boundaries of individual firms and that a multitude of actors may be needed to realize a particular BM (e.g., Zott, Amit et al., 2011; Berglund and Sandström, 2013). Nevertheless, a BM still centers around a focal firm whose means of value creation, delivery, and capture the BM aims to illustrate (Zott, Amit et al., 2011). This implies that each BM is in some way unique to the firm that uses it, even if BMs often share similar features that makes it possible to distinguish common types that are used by more than one firm on a market (e.g., Bocken, Short et al., 2014).

The framework developed by Richardson (2008) captures similar themes and elements of many other prominent BM frameworks (e.g., Alt and Zimmermann, 2001; Amit and Zott, 2001; Johnson, Christensen et al., 2008; Osterwalder and Pigneur, 2010), and focuses on three components: value proposition, value creation and delivery system, and value capture.

- The *value proposition* reflects what the organization delivers to its customers, who these customers are, and why they will be willing to pay for what the firm offers.
- The *value creation and delivery system* present how the organization creates and delivers the value proposed to its clients and the source of its competitive advantage. This includes the firm's resources and

Table 2
Roles, activities, and application associated with solar PV.

Roles	Description
Property owner	Owner of the land or building on which the solar PV system is located.
Solar PV system owner	Owner of the solar PV system who is responsible for financing, procurement, construction, and installation of the technology.
Consumer	Actor that consumes or sells the electricity produced by the solar PV system.
Activities	**Description**
Project development	Includes solar PV system engineering, conducting pre-studies, applying for building permits, identifying users, property-, and system owners.
Technology sales	Acquiring and selling solar PV components.
Construction & installation	Includes project management as well as construction and electrical installation of the solar PV system.
Application	**Description**
Residential (5–10 kW)	Roof-mounted systems targeting private households.
Commercial (10–250 kW)	Primarily roof-mounted systems targeting owners of commercial properties, agriculture barns, apartment buildings, and public properties.
Industrial (>250 kW)	Roof-mounted systems targeting industrial property owners.
Utility (>1 MW)	Ground-mounted systems targeting utilities, large businesses, and community groups.

capabilities, its organization (e.g., activity system) and its position in the value network.
- *Value capture* describes how the organization generates revenue and profit.

Richardson (2008)'s framework has the advantage that it focuses on the concept of value, which is central for any firm's BM, and that it covers the overall elements of a BM, in a way that enables comparison between many different BMs. In this paper, we use the BM framework developed by Richardson (2008) in order to understand solar BMs from a focal firm perspective by combining it with the key differentiating factors highlighted in solar PV- and policy literature: roles, activities and application.

3. Method

To better understand how solar BMs presented in literature compare with BMs of solar firms that deploy the technology, we mapped and analyzed the BMs of 241 firms involved in sales, project development, and installation of solar PV in Sweden.

3.1. The context of Sweden

Although many different solar BMs have been identified (as shown in Section 2.1.1.), all are not used to the same extent around the world. Due to local factors, the prevalence and design of solar BMs vary between countries (e.g. Strupeit and Palm, 2016) and BMs need to be translated from one context to another in order to be successfully employed (Ode and Wadin, 2019). This implies that the choice of context is important when studying solar BMs and that local factors should be considered when choosing study context. In our study, Sweden was selected for several reasons.

Since the liberalization of the electricity market in the late nineties, many firms have joined the Swedish market to either produce renewable electricity (both in centralized and decentralized manners) or to offer services related to the support of RET adoption (e.g. Bergek, Mignon et al., 2013; Bergek, 2020). In terms of solar PV deployment, although Sweden is not at the forefront with regard to installed capacity, it is above the global average in terms of distributed solar PV per capita (Palm and Lantz, 2020). The Swedish solar PV market has also grown exponentially over the past decade, which has been fueled by e.g., a direct capital subsidy system, declining system prices, and high public interest (Lindahl, Berard et al., 2021; Lindahl, Lingfors et al., 2022). As a result, new types of BMs and market segments have appeared.

The International Energy Agency's Photovoltaic Power Systems Programme (https://iea-pvps.org/) reports data every year on the technical, economic, environmental and social aspects of PV power systems in Sweden (i.e., Lindahl, Berard et al., 2021). Another motivation for choosing Sweden as the empirical setting of this paper is therefore that we had access to this database. The database contains information about 741 known organizations that are, or have been, involved with solar technologies in Sweden. This provides a reliable and comprehensive list of firms that served as a basis for our data collection. This information includes organizational name, link to website, founding year, if the firm has been liquidated, type of solar technology, and primary business focus (e.g., manufacturing, research, sales, consulting, and installation).

3.2. Selection of firms

Among the organizations included in the database, we selected the 351 firms that were categorized according to the primary business focus of sales, consulting, and installation of solar PV. This sample was made on the basis that these firms were considered to have BMs with the most direct influence on the deployment of solar PV, which, in turn, was based on the characteristics of activities associated with the solar PV value chain (Fig. 1, section 2.1.2.). In this study, we selected firms focusing on one-shot downstream activities (i.e., project development, technology sales, and construction and installation) since their businesses are built around the implementation of solar PV systems and hence have a direct impact on the deployment of solar PV. This does not imply that firms that focuses on upstream activities or ongoing downstream activities are unimportant for the deployment of solar PV, only that their influence is less direct, e.g., by making the technology affordable and system ownership hassle-free to more users.

Furthermore, we excluded Swedish utility firms from our sample on the basis that they primarily outsource their solar business to local installation firms (Lindahl, Berard et al., 2021) and that their BMs have been the focus of recent studies (e.g., Altunay, Bergek et al., 2021). To enable comparison with the solar BMs in literature we also excluded firms that focused on "non-standard" solar PV (i.e., building-integrated or off-grid solutions) (Lindahl, Berard et al., 2021) and only targeted other solar businesses (e.g., wholesalers). A screening was also conducted during data collection where firms that lacked websites or did not provide any information to indicate that they engaged in sales, project development, or installation of solar PV, were excluded. This resulted in a final inclusion of 241 solar firms.

3.3. Data collection and analysis

To map the components of the selected solar firms' BMs, secondary data was collected from the firms' websites[1] (April–September 2021), in

[1] If firm websites did not exist, the firms' social media pages on Facebook, Instagram or Linkedin were searched for information regarding their BMs.

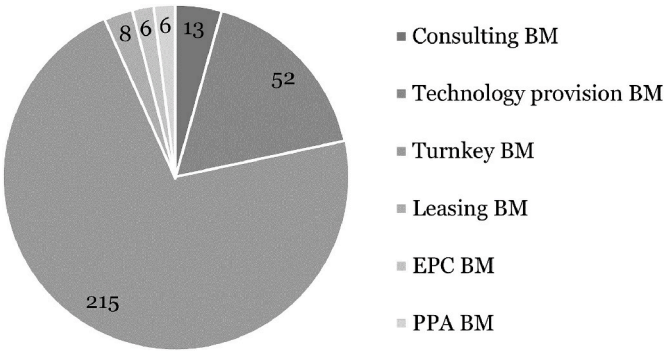


Fig. 2. Number of solar BMs used by firms in Sweden.[2].

line with the BM framework by Richardson (2008). This included information about target customer segments, different offers, the activities involved in creating and delivering these offers, who performs these activities, and how revenues are structured. If information regarding a BM component was not available, the section was left blank. We also noted down if the firms emphasized certain aspects of their BM, e.g., referring to themselves as turnkey or PPA providers.

The data was subsequently compared and categorized based on roles, activities, and application (Table 2) to enable comparison with solar BMs described in literature (Section 2.1).

Although many of the solar firms did not explicitly state who took on the roles of property owner, system owner or consumer, these patterns could be discerned based on the descriptions of the offer and activities performed to create and deliver these. Similarly, the exact application and project size were not presented on the firms' websites so, instead, we used market segments as an indicator, based on Lindahl, Berard et al. (2021).

4. Findings

By mapping and analyzing the BMs of firms involved with sales, project development, and installation of solar PV in Sweden, we identified six types of solar BMs that firms use to communicate their offer to potential and existing clients: (1) consulting-, (2) technology provision-, (3) turnkey-, (4) leasing-, (5) engineering, procurement, and construction (EPC)-, and (6) power purchase agreement (PPA) BMs. These are differentiated based on their BM components: value proposition, value creation and delivery, and value capture, as presented in the BM framework by Richardson (2008). The solar BMs also display patterns related to the roles, activities, and applications associated with solar PV, as described in the following sections (for an overview of the full analysis, see Appendix).

As illustrated in Fig. 2, the turnkey BM is the most recurrent BM on the Swedish solar market, followed by the technology provision BM, and the consulting BM. Leasing-, EPC- and PPA BMs are in contrast somewhat rare among solar firms active on the Swedish market. Notably, our findings show that some solar firms use more than one solar BM and that several of them use other types of BMs in parallel with their solar BM. For instance, the solar consulting BM is often combined with other types of civil engineering services, and many solar turnkey providers also offer other types of electricity or energy system services, thus utilizing their expertise for other markets and customer segments.

4.1. Consulting business model

The value proposition of the consulting BM is to offer ad-hoc services related to project development of solar PV systems to customers wanting input from an impartial actor (i.e., not a technology provider). Targeted customers primarily consist of municipalities looking to acquire and install a solar PV system on a public property for electricity self-consumption, but they also include owners of industrial-, commercial-, and apartment properties. As such, the BM spans the commercial and industrial application types, and the customer is the one taking the roles of property owner, PV system owner, and electricity consumer (Fig. 3). The services related to project development include pre-studies (e.g., to determine the profitability of different solutions), engineering, and tendering evaluation. Customers are free to select which of these services they want to acquire, and the solar consultancy firms utilize their impartial position and the expertise of their personnel to create and deliver this value. In exchange, they can capture value by charging customers an hourly or daily fee for the services they provide.

Some solar consultancy firms also have the technical expertise to extend their offer into activities such as construction and installation, monitoring, and operation and maintenance of solar PV systems. While offering services related to construction and installation (e.g., project management and solar PV system inspection) provide opportunities for exploiting competences needed for one-shot activities, monitoring and maintenance of solar PV systems that are up and running also generate recurring revenues. By extending their offer into ongoing activities, solar firms can thus exploit their customer relationships and continue to create, deliver, and capture value.

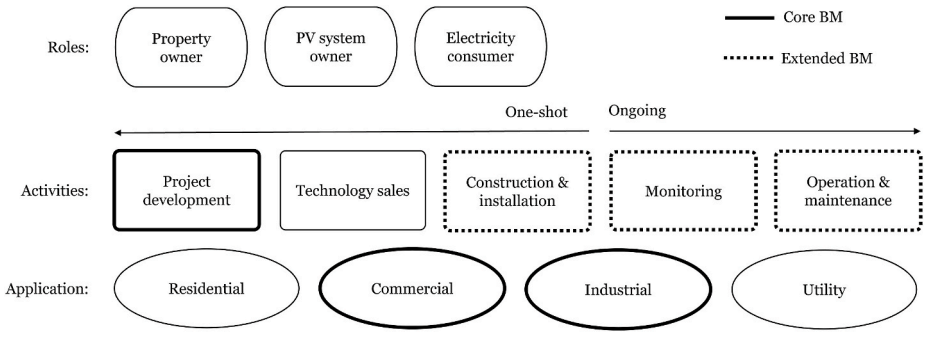


Fig. 3. Roles, activities, and applications of the consulting BM.

[2] Note that the total number exceed the 241 solar firms included in the study as some firms use more than one solar BM.

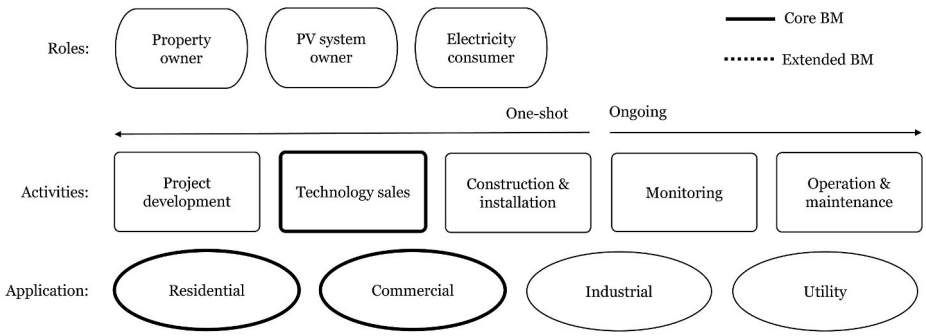


Fig. 4. Roles, activities, and applications of the technology provision BM.

4.2. Technology provision business model

Firms with a technology provision BM focus on selling solar PV technology in small batches to private households, farmers, and commercial property owners that wish to develop and install a solar PV system on their property themselves for self-consumption purposes (Fig. 4). According to Swedish law, solar PV systems must be installed by certified personnel and electricians, so these customers must possess, or have access to, these competences. Solar firms with this BM are, thus, specialized in the technology sales activity with a residential and commercial application type. Customers take on the roles of property owner, PV system owner, and electricity consumer. Customers are also required to possess the competences needed for solar PV system development, construction, and installation.

The value that is proposed in this BM is to provide customers with the components required for installing a solar PV system (e.g., solar panels, inverters, racking). Here, customers can often choose between purchasing individual components or complete solar packages that includes all the components needed for a standardized solar PV system. The technology providers create and deliver this value by acquiring large quantities of different components from wholesalers or manufacturers and combining them into packages. In exchange, technology providers can capture value by selling the components at a higher price than what they purchased them for.

Some technology providers also offer complementary products in addition to solar PV, such as electric vehicle (EV) chargers, heat pumps, and solar batteries. These products are often offered as complements to solar PV systems since they provide additional value to customers when used together, and they are often acquired simultaneously.

4.3. Turnkey business model

The most prevalent BM used by solar firms in Sweden is the turnkey BM, in which customers are offered a complete solar PV system that is tailored to their preconditions and ready for immediate use through a hassle-free process. This solution is offered to a wide range of customers, but the primary target segments include private households, farmers, commercial-, and apartment property owners. It is rare for turnkey providers to only target one customer segment, instead, most of them target several ones (although the specific combination varies). The turnkey BM spans the residential and commercial applications, and the customer takes on the roles of property owner, PV system owner, and electricity consumer.

Turnkey providers create and deliver value to their customers by managing all activities in the one-shot downstream part of the value chain (Fig. 5). Commonly, parts of the installation process are carried out in partnerships with subcontractors, but the turnkey provider remains the sole point of contact for the customer during the entire process until the solar PV system is up and running. Once the system has been installed, a one-time payment for the complete solution is paid by the customer.

Several variations of the turnkey BM can be found among solar firms in which they extend the core offer with services to provide an even more complete and hassle-free solution. In many cases, this means extending into ongoing activities, such as solar PV system monitoring and maintenance, but also by acting as intermediary between the solar PV system owner and financial institutions that can provide options for financing the system (e.g., deferred payment plans, solar loans). Other notable variations of the BM include providing complementary products and services such as roofing and/or procurement and installation of EV chargers, solar batteries, and heat pumps.

Some turnkey providers have also extended their core offer with options that are tailored to a specific customer segment. One example is providing individual billing solutions to apartment building owners so that the solar electricity consumption can be measured and paid for by each individual apartment. A variation in the turnkey BM can also be observed in terms of how value is created and delivered by the solar firm. More specifically, some turnkey providers emphasize that they possess all the necessary competence in-house. They argue that by not partnering up with subcontractors they can maintain full control of the entire installation process.

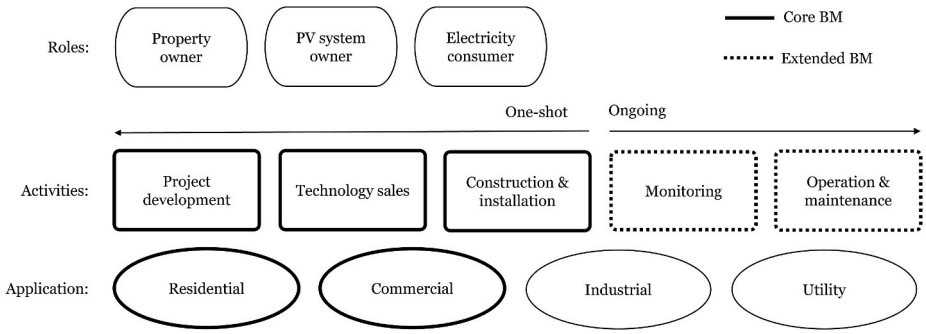


Fig. 5. Roles, activities, and applications of the turnkey BM.

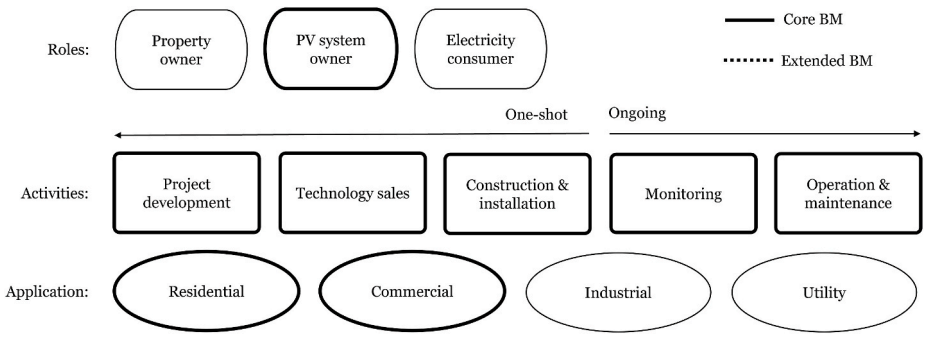


Fig. 6. Roles, activities, and applications of the leasing BM.

4.4. Leasing business model

The leasing BM exists to a limited extent in Sweden and is primarily targeted at commercial property owners, but in some cases also private households, farmers, apartment-, and public property owners (i.e., residential and commercial application). In this BM, customers are offered access to a solar PV system that is installed on their roof that they can use for production and consumption of electricity. As such, they do not own the solar PV system and are spared from operational responsibility and upfront costs associated with PV system ownership. Instead, the leasing providers take on the responsibility of all downstream activities, including solar PV system financing, monitoring, operation, and maintenance associated with technology ownership (Fig. 6). In exchange, customers provide access to their roof and enter into a lease agreement in which they agree to pay a monthly cost for using the solar PV system over a set period (e.g., 5, 10, or 20 years). As such, the customer still retains the roles of property owner and electricity consumer.

Despite its limited use in Sweden, some variations in the leasing BM could be observed. One example includes using crowdfunding as means to finance solar PV systems in which capital is obtained from individuals that are looking for a secure and long-term return on investment. Another example is to offer leasing through partnerships, where the leasing provider enters an exclusive partnership with a third-party firm that finances and owns the solar PV system (i.e., outsources the PV system ownership). The core offer to the customers remains the same in these variations of the leasing BM but the value is delivered by different means.

4.5. Engineering, procurement, construction business model

Another solar BM that is only used to a limited extent in Sweden is the EPC BM. EPC stands for engineering, procurement, and construction, and it is commonly associated with a form of contract that is used for large-scale construction projects. The EPC[3] BM resembles the turnkey BM in that it involves the same type of activities associated with the solar PV value chain and that customers are offered a complete and hassle-free solar PV system solution (Fig. 7). However, the difference in scale brings with it some major differences in the BM components.

Firstly, the EPC BM involves the construction and installation of large-scale solar PV systems (e.g., solar parks) and so it is primarily targeted at large businesses, utilities, and industrial property owners (i.e., industrial and utility application). The EPC solution also includes more activities before, during, and after the installation in comparison to a turnkey solution. For instance, EPC providers are involved in identifying and securing access to suitable locations for the solar PV system if customers do not own appropriate properties themselves. As such, the role of property owner is not necessarily held by the customer, but it is also not held by the EPC provider. PV system owner and electricity consumer are roles associated with the customer in this BM.

The scale of operations also necessitates partnerships and collaborations with not only financial institutions, but also municipalities, local communities, and grid-operators. In terms of value capture, offering monitoring and maintenance services enables EPC providers to obtain predicable revenue streams through periodic payments in addition to the payments received from their solar construction projects.

4.6. Power purchase agreement business model

Lastly, the PPA BM is used by a handful of solar firms in Sweden. PPA

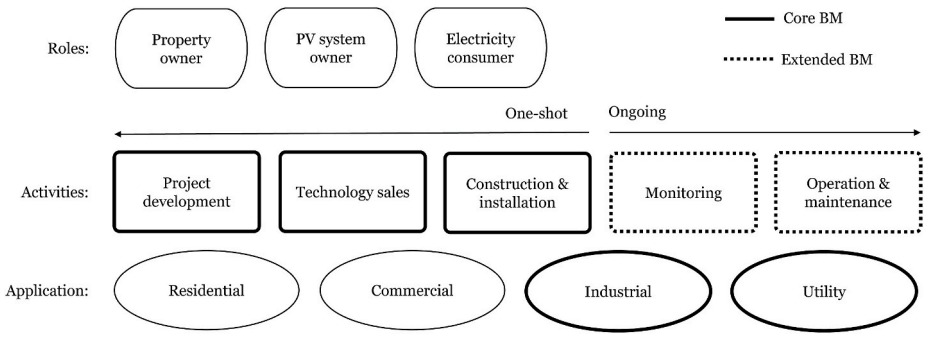


Fig. 7. Roles, activities, and applications of the EPC BM.

[3] Note that EPC projects are sometimes referred to as turnkey construction projects.

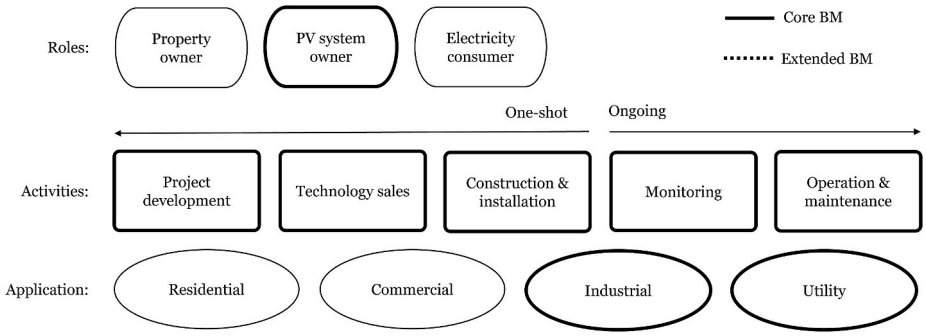


Fig. 8. Roles, activities, and applications of the PPA BM.

stands for power purchase agreement and it is a form of contract in which a customer agrees to purchase electricity from a provider over a set period (e.g., 10, 15, 25 years in the case of solar) through periodic payments. The focus of the PPA BM is to provide customers with solar electricity (i.e., not a solar PV system per se). Like the EPC BM, the PPA BM involves large-scale solar PV systems (e.g., solar parks) and it primarily targets large businesses, thus differing from e.g., the leasing BM in terms of application (Fig. 8). The length of contracts provides customers with long-term predictable supply of electricity at a fixed price which, in turn, hedges against spot price fluctuations on the electricity market. In the PPA BM, the produced solar electricity is not directly used by customers, instead it is fed onto the grid and customers are provided with Guarantees of Origin (GOs) that links the production to their consumption.[4]

Like in the leasing BM, PPA providers create and deliver value to customers by taking on the responsibility for the entire downstream activities, as well as PV system financing, monitoring and maintenance associated with system ownership. However, like the EPC BM, the large-scale of solar PV systems require partnerships and collaboration with financial institutions, landowners, municipalities, local communities, and grid-operators. The solar PV systems are also primarily ground-based, meaning that project development also involves identifying a suitable location and agreement with the property owner. As such, the customer only takes on the role of electricity consumer in the PPA BM, whereas the PPA provider takes on PV system ownership, and the property owner is an external party.

5. Discussion

Through the empirical study of solar BMs used by solar firms in Sweden, we found several interesting results that have implications for strategy and policy design.

To start with, our findings show that the most prevalent solar BMs in Sweden are oriented towards residential and commercial applications and host-owned solar PV systems. In contrast, BMs involving industrial and utility-scale applications and TPO systems are scarce. This is not very surprising, since over the past 10 years, policies in Sweden have targeted households and small property owners through investment subsidies. Nevertheless, this clearly shows how much policies have an impact on the success or the lack of diffusion of BMs. In the specific case of Sweden, it is crucial that policymakers understand that if they want to increase the variety of some BMs, e.g., leasing or PPA BMs, they should also develop policies that incentivize solar firms or other actors to take on the role of solar PV system owner. In a larger context, our results show that it is important for policymakers to have good knowledge of the BMs used by solar firms on the market in order to fully understand the impact that policies have on some BMs, the solar firms using them, and the targeted market segments.

Secondly, our empirical results show that the solar firms design and communicate their BMs with customers in focus, which is different from the logic assumed in the previous solar BM literature. As Richardson (2008) proposes, the logic of solar firms and their BMs is centered on "Who is our customer?", "What does the customer need?" and "How can we fulfill this need as a way to capture value?". Such needs differ greatly between different customer segments, and this is not captured by the BM categorizations proposed in most of the past research where solar BMs are described and classified based on aspects such as roles, activities, and application (see Section 2.1.). This indicates that there is a mismatch between, on the one hand, the way energy policy- and solar BM scholars understand and communicate solar BMs, and, on the other hand, the way market actors, such as firms, perceive and communicate solar BMs to their stakeholders.

To exemplify, solar BM literature view farmers, apartment building owners, commercial property owners, and municipalities as one cohesive group of investors that can be targeted using a commercial application BM (e.g., Burger and Luke, 2017), whereas solar firm acknowledge the specific needs of these customer segments and design their BMs to offer targeted solutions, such as individual billing for apartments or impartial support during tendering for municipalities.

Another illustrative example of the mismatch is the community solar BM. This BM has received specific attention in solar BM literature (e.g. Huijben and Verbong, 2013; Nolden, Barnes et al., 2020) and policymakers consider it as one of the important solar BMs to democratize the energy system and to encourage citizen participation in the energy transition (European Commission, 2017; Cohen, Azarova et al., 2021). Yet, none of the 241 solar firms included in our study has a community solar BM. This does not mean that solar firms are not involved in building community solar PV systems, or that communities do not invest in or use solar PV in Sweden, but it shows that none of the solar firms included in our sample sees the need to design their BM to target this specific market segment. Hence, if policymakers aim to influence the market for solar PV in order to e.g., attract new market actors by increasing the use of some BMs, they need to develop a better understanding of solar BMs from what is valuable for the firm and its customers. In the specific case of community solar, if policymakers want to increase the share of communities in solar PV production, we suggest that they start by communicating better with solar firms and by developing targeted policies aimed at increasing the demand from community groups, hence making them an interesting target group to solar firms.

Thirdly, the results show that even though solar firms perform the same activities in relation to the solar PV value chain, their BMs may differ. For instance, as illustrated in Sections 4.4.-4.6. turnkey- and EPC BMs, and leasing- and PPA BMs include the same activities and roles for solar firms, but, as suggested by Burger and Luke (2017), the level of complexity and the firm capabilities needed to realize these BMs are different depending on the size of projects (i.e., application). For instance, EPC- and PPA BMs require large amounts of financial

[4] This setup is sometimes referred to as virtual PPA to distinguish it from a physical PPA (in which the produced electricity is transferred physically) which is a solution that was not observed among the solar firms included in our study.

resources, vast networks with utilities, grid owners, financial investors, etc., and are substantially more complex than smaller projects delivered through turnkey- or leasing BMs. This distinction is important for both managers and policymakers. Policymakers must be aware that the profiles of firms with EPC- and PPA BMs are different from those with turnkey- and leasing BMs. Due to the complexity of projects, solar firms with EPC- and PPA BMs can expect higher value capture than firms with turnkey- and leasing BMs. Meanwhile, policymakers must be aware that due to different levels of financial stability or value capture models, firms are more or less sensitive to policy changes, and may react differently to incentives and take different types of risks.

As suggested in Section 2.1. our results reveal that several of the empirical BMs that solar firms use are included under the umbrella of theoretical solar BMs that have been discussed in previous literature. For instance, the host-owned BM cover consulting-, technology provision-, turnkey, and EPC BMs. Similarly, as suggested by Tongsopit, Moungchareon et al. (2016), leasing- and PPA BMs are two different BMs that are both covered by the TPO BM. This difference in categorization may seem shallow, but it is in fact a problem that has serious consequences both for research and policymakers. Evidently, the empirical solar BMs included in the theoretical solar BMs target different market segments, require different types of competences from the firms using them, and include different activities. For policymakers, using the theoretical solar BM categorization, rather than the BMs used by solar firms is, thus, a missed opportunity. Indeed, a deeper understanding of the empirical solar BMs may be a way to reach specific market segments (e.g., public organizations, large firms, homeowners) or different types of suppliers (small and medium-sized enterprises or utilities). A deeper understanding of the solar BMs dominating the market may also be an indication of the current weaknesses of the solar energy system. For instance, our results suggest that firms with competences in large solar project development are scarce, while firms with competences in small solar projects are many. If policymakers want to encourage larger solar projects, it is important to consider that competences are concentrated among very few actors.

Our findings also show that some solar firms use solar BMs in parallel and that many operate on other markets simultaneously. Hence, in line with e.g., Benson-Rea, Brodie et al. (2013) and Casadesus-Masanell and Tarziján (2012), our results show that solar firms build on their existing resources and capabilities by using their solar BMs in parallel with complementary BMs and finding synergies. From a policy perspective, this means that if policymakers want to encourage BMs targeting specific market segments, they should be aware that BMs require specific competences, and they may have a role to play in ensuring that necessary resources and competences are available to market actors. This also leads us to stress the fact that future research should consider that each firm has a unique BM or set of BMs.

6. Conclusion and policy implications

The aim of this paper was to bridge the gap between, on the one hand, the way energy policy literature describes solar BMs, and, on the other hand, the way solar firms use solar BMs to communicate their offers to customers, how they organize their activities and resources, and how they create value for customers and themselves. To reach this aim, the BMs of 241 solar firms in Sweden were mapped and analyzed with the use of an extended version of the BM framework by Richardson (2008) that includes dimensions highlighted in solar BM literature, namely roles, activities, and application.

Six types of solar BMs that solar firms use to communicate their offer to customers were identified: consulting-, technology provision-, turnkey-, leasing-, EPC-, and PPA BMs. These differs in terms of their value proposition, value creation and delivery, and value capture, and display different patterns in relation to the roles, activities, and application associated with solar PV. The prevalence of the solar BMs varies greatly in Sweden where BMs that are oriented towards small-scale- and host-owned solar PV systems (e.g., turnkey BM) are used many firms, and BMs focusing on large-scale- and TPO systems are scarce.

The analysis of our findings shows a mismatch between, on the one hand, the way energy policy- and solar BM scholars understand and categorize solar BMs, and, on the other hand, the way firms use solar BMs and how they communicate solar BMs to their stakeholders. While the energy policy- and solar BM literature describes and classifies solar BMs based on what roles related to e.g., solar PV system ownership firms and their clients take, what activities are performed, or what size of system is applied, empirically, solar firms focus on customers. This logic includes what needs customers have and what value is delivered to them (e.g., in how comprehensive, reliable, and hassle-free the solution is). Understanding this logic opens new avenues for understanding the solar PV market, both in Sweden and in other countries. It shows new similarities and differences between solar firms, e.g., in terms of targeted customer segments, value proposition, capabilities and parallel BMs.

Exploring solar firms from this new perspective should be considered by future research. In particular, understanding how solar firms design their strategies and BMs, and how policies (or other factors) can induce or hamper solar firms to develop certain solar BMs are questions that may provide interesting new knowledge to be applied into policy design. Indeed, when communicating with market actors and when designing policies aimed at stimulating the demand of solar PV technology, it is of crucial importance that policymakers understand the perspective of firms that are providing and installation the technology. The risk is otherwise (as discussed with the example of solar community BM) that firms and policymakers over- or underestimate the importance of a market segment, or that policymakers misinterpret the impact of some policies on the market for solar PV.

As a matter of fact, it is not only the perspective of solar firms that is overlooked in the energy policy literature. Much of the research on solar BM make assumptions about how policymakers perceive and understand solar BMs without actually asking them. Taking an empirical approach to better understand the perspective of policymakers may shed a light on potential mismatches between policymakers' perceptions and goals and the theoretical understanding of energy policy literature.

When considering a firm perspective on solar BMs, our results underline the importance of firms' capabilities (e.g., skills related to import or electricity and capital needed to invest in large solar PV systems) in the choice and design of their solar BMs. Additionally, the studied solar firms build on their existing resources and capabilities by combining their solar BMs with complementary BMs. These findings pose questions such as: What are the existing capabilities among solar firms? What complementarities are there in the capabilities of firms operating in the solar PV market? What is the impact of a lack (or an overflow) of some capabilities among solar firms? What is the link between solar firms' capabilities and their BMs? These questions are of utmost importance for future research, as they appear to be determinant for market strategies of firms. In a fast-changing market such as solar PV, it is also crucial that the competences needed for deployment are available on the market, and this is a domain where policymakers have a role to play.

Our study has focused on firms based in Sweden. Despite indications that the variety of solar BMs in Sweden has similarities with other countries (e.g. Schoettl and Lehmann-Ortega, 2011), it is expected that the BM categories present in Sweden may be different from those present in other countries. We therefore encourage further research to perform similar empirical studies in other contexts considering different solar BM variants.

CRediT authorship contribution statement

Amanda Bankel: Data collection and analysis, Writing – original and revised draft, Review & Editing. **Ingrid Mignon:** Conceptualization, Writing – original and revised draft, Review & Editing, Funding acquisition, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We are grateful to Dr. Johan Lindahl for supporting during the data collection and providing valuable comments during the writing of the article. The funding support of the Swedish Energy Agency (Innovative business models for a large-scale diffusion of solar PV, grant no. P48527-1) is also gratefully acknowledged.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.enpol.2022.113013.

References

Alt, R., Zimmermann, H.-D., 2001. Introduction to special section-business models. Electronic Markets-The International Journal 11 (1), 1019–6781.
Altunay, M., Bergek, A., Palm, A., 2021. Solar business model adoption by energy incumbents: the importance of strategic fit. Environ. Innov. Soc. Transit. 20, 501–520.
Amit, R., Zott, C., 2001. Value creation in e-business. Strat. Manag. J. 22 (6-7), 493–520.
Aspeteg, J., Mignon, I., 2019. Intermediation services and adopter expectations and demands during the implementation of renewable electricity innovation – match or mismatch? J. Clean. Prod. 214, 837–847.
Benson-Rea, M., Brodie, R.J., Sima, H., 2013. The plurality of co-existing business models: investigating the complexity of value drivers. Ind. Market. Manag. 42 (5), 717–729.
Bergek, A., 2020. Diffusion intermediaries: a taxonomy based on renewable electricity technology in Sweden. Environ. Innov. Soc. Transit. 36, 378–392.
Bergek, A., Mignon, I., Sundberg, G., 2013. Who invests in renewable electricity production? Empirical evidence and suggestions for further research. Energy Pol. 56 (56), 568–581.
Berglund, H., Sandström, C., 2013. Business model innovation from an open systems perspective: structural challenges and managerial solutions. Int. J. Prod. Dev. 18 (3–4), 274–285.
Bidmon, C.M., Knab, S.F., 2018. The three roles of business models in societal transitions: new linkages between business model and transition research. J. Clean. Prod. 178, 903–916.
Bocken, N., Short, S., Rana, P., Evans, S., 2014. A literature and practice review to develop sustainable business model archetypes. J. Clean. Prod. 65, 42–56.
Bolton, R., Hannon, M., 2016. Governing sustainability transitions through business model innovation: towards a systems understanding. Res. Pol. 45 (9), 1731–1742.
Burger, S.P., Luke, M., 2017. Business models for distributed energy resources: a review and empirical analysis. Energy Pol. 109, 230–248.
Casadesus-Masanell, R., Tarziján, J., 2012. When One Business Model Isn't Enough.
Cohen, J.J., Azarova, V., Kollmann, A., Reichl, J., 2021. Preferences for community renewable energy investments in Europe. Energy Econ. 105386.
Drury, E., Miller, M., Macal, C., Graziano, D., Heimiller, D., Ozik, J., Perry IV, T., 2012. The transformation of southern California's residential photovoltaics market through third-party ownership. Energy Pol. 42, 681–690.
European Commission, 2017. The Strategic Energy Technology (SET) Plan. D.-G. f. R. a. Innovation.
Ford, R., Walton, S., Stephenson, J., Rees, D., Scott, M., King, G., Williams, J., Wooliscroft, B., 2017. Emerging energy transitions: PV uptake beyond subsidies. Technol. Forecast. Soc. Change 117, 138–150.
Frantzis, L., Graham, S., Katofsky, R., Sawyer, H., 2008. Photovoltaics Business Models. Burlington. National Renewable Energy Lab.(NREL), Golden, CO (United States).
Horváth, D., Szabó, R.Z., 2018. Evolution of photovoltaic business models: overcoming the main barriers of distributed energy deployment. Renew. Sustain. Energy Rev. 90, 623–635.
Huijben, J., Verbong, G., 2013. Breakthrough without subsidies? PV business model experiments in The Netherlands. Energy Pol. 56, 362–370.
Huijben, J., Verbong, G., Podoynitsyna, K., 2016. Mainstreaming solar: stretching the regulatory regime through business model innovation. Environ. Innov. Soc. Transit. 20, 1–15.
IEA, 2021. Net Zero by 2050 - A Roadmap for the Global Energy Sector. International Energy Agency, Paris. https://www.iea.org/reports/net-zero-by-2050.
Johnson, M.W., Christensen, C.M., Kagermann, H., 2008. Reinventing your business model. Harv. Bus. Rev. 86 (12), 57–68.
Karneyeva, Y., Wüstenhagen, R., 2017. Solar feed-in tariffs in a post-grid parity world: the role of risk, investor diversity and business models. Energy Pol. 106, 445–456.
Lindahl, J., Berard, J., Oller Westerberg, A., Vanky, K., 2021. National Survey Report of PV Power Applications in Sweden 2020. IEA PVPS Task 1. Sweden. International Energy Agency. https://iea-pvps.org/wp-content/uploads/2021/10/National-Survey-Report-of-PV-Power-Applications-in-Sweden-2020.pdf.
Lindahl, J., Lingfors, D., Elmqvist, Å., Mignon, I., 2022. Economic analysis of the early market of centralized photovoltaic parks in Sweden. Renew. Energy 185, 1192–1208.
Massa, L., Tucci, C.L., Afuah, A., 2017. A critical assessment of business model research. Acad. Manag. Ann. 11 (1), 73–104.
Mignon, I., Bergek, A., 2016. Investments in renewable electricity production: the importance of policy revisited. Renew. Energy 88, 307–316.
Mignon, I., Rüdinger, A., 2016. The impact of systemic factors on the deployment of cooperative projects within renewable electricity production – an international comparison. Renew. Sustain. Energy Rev 65, 478–488.
Nolden, C., Barnes, J., Nicholls, J., 2020. Community energy business model evolution: a review of solar photovoltaic developments in England. Renew. Sustain. Energy Rev. 122, 109722.
Ode, K.A., Wadin, J.L., 2019. Business model translation—the case of spreading a business model for solar energy. Renew. Energy 133, 23–31.
Osterwalder, A., Pigneur, Y., 2010. Business Model Generation: a Handbook for Visionaries, Game Changers, and Challengers. John Wiley & Sons, Hoboken, New Jersey.
Överholm, H., 2015. Spreading the rooftop revolution: what policies enable solar-as-a-service? Energy Pol. 84, 69–79.
Palm, A., Lantz, B., 2020. Information dissemination and residential solar PV adoption rates: the effect of an information campaign in Sweden. Energy Pol. 142, 111540.
Palm, J., Tengvard, M., 2011. Motives for and barriers to household adoption of small-scale production of electricity: examples from Sweden. Sustain. Sci. Pract. Pol. 7 (1).
Proka, A., Beers, P., Loorbach, D., 2018. Transformative Business Models for Sustainability Transitions. Sustainable Business Models. Springer, Switzerland, pp. 19–39.
Richardson, J.E., 2008. The business model: an integrative framework for strategy execution. Strat. Change 17, 133–144.
Sarasini, S., Linder, M., 2018. Integrating a business model perspective into transition theory: the example of new mobility services. Environ. Innov. Soc. Transit. 27, 16–31.
Sauter, R., Watson, J., 2007. Strategies for the deployment of micro-generation: implications for social acceptance. Energy Pol. 35 (5), 2770–2779.
Schoettl, J.-M., Lehmann-Ortega, L., 2011. Photovoltaic Business Models: Threat or Opportunity for Utilities? Handbook of Research on Energy Entrepreneurship. Edward Elgar Publishing, Cheltenham.
Strupeit, L., Palm, A., 2016. Overcoming barriers to renewable energy diffusion: business models for customer-sited solar photovoltaics in Japan, Germany and the United States. J. Clean. Prod. 123, 124–136.
Teece, D.J., 2010. Business models, business strategy and innovation. Long. Range Plan. 43 (2–3), 172–194.
Tongsopit, S., Moungchareon, S., Aksornkij, A., Potisat, T., 2016. Business models and financing options for a rapid scale-up of rooftop solar power systems in Thailand. Energy Pol. 95, 447–457.
Vasileiadou, E., Huijben, J., Raven, R., 2016. Three is a crowd? Exploring the potential of crowdfunding for renewable energy in The Netherlands. J. Clean. Prod. 128, 142–155.
Wirtz, B.W., Pistoia, A., Ullrich, S., Göttel, V., 2016. Business models: Origin, development and future research perspectives. Long. Range Plan. 49 (1), 36–54.
Wüstenhagen, R., Menichetti, E., 2012. Strategic choices for renewable energy investment: conceptual framework and opportunities for further research. Energy Pol. 40, 1–10.
Zhang, S., 2016. Innovative business models and financing mechanisms for distributed solar PV (DSPV) deployment in China. Energy Pol. 95, 458–467.
Zott, C., Amit, R., Massa, L., 2011. The business model: recent developments and future research. J. Manag. 37 (4), 1019–1042.