Demand-side management and renewable energy business models for energy transition

A systematic review

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Abstract

Recent developments in technology have been considered a critical factor in fighting climate change and accelerating energy transition. These developments are changing the current centralized and fossil fuel-based energy system into a new system with integrated renewable energy resources. The developments also facilitate the emergence of new business models and allow entrepreneurs to propose new products and services. This paper aims to identify the existent energy business models based on a systematic literature review, focusing on two main areas: renewable energy and demand-side management. With that purpose, a framework is described including specific characteristics for energy business models. Based on this framework, 22 different energy business models are presented clustered in eight patterns. The study draws on an exhaustive picture of the emerging business models and provides insights for researchers and for early-stage companies to innovate through business model transformation.

Key words

Business model, energy services, energy entrepreneur, renewable energy, demand-side management, demand response.

Introduction

Recently, an international effort went into decarbonisation of the energy sector in order to mitigate climate change (DDPP, 2015). This sector accounts for 46 percent of world's emissions as natural gas, coal and oil are the main elements of electricity generation, heating and cooling (Davis, Caldeira and Matthews, 2010). Moreover, considerable political efforts have been put into liberalizing energy markets. Since that time, the rules, roles and business models of the conventional actors in the energy sector have been increasingly changing. Energy utilities have been pushed to deliver additional services such as energy advice rather than to increase energy sales. Competitive market principles are taking the place of the traditional role of energy utilities as public goods providers.

In parallel, the distributed energy resources (DERs), such as renewables, are increasingly expanding, and they depend on a different logic compared with centralized, large-scale power plants. They yield significant benefits regarding carbon emissions and may contribute to reducing losses in energy distribution. However, building decentralized sustainable energy systems requires a high degree of integration of these local, independent small-scale renewables. This shift from a planned system, in which the state decides what and how to produce and who pays, to a competitive and two-sided market can be understood through the business model concept, which defines how to capture value from new markets. The deployment of renewable energy technologies through sustainable business models opens up access to new entrepreneurs to participate in the energy transition.

Antoncic and Hisrich (2003) indicate that entrepreneurship is a proactive concept that operates at the organizational boundary and extends current technologies, products, services, norms, etc. into new directions. Noticeably, energy entrepreneurs, who are looking to detect new possibilities emerging from the intersection of sustainability and the energy domain, are contributing to the energy transition by commercializing discontinuous innovations and breakthrough technologies (Elgar, 2011).

Analysing the difficulties of emerging business models in the energy sector requires identifying specific business model characteristics for this sector and analysing the relationship between different stakeholders. Often, business model innovation is introduced by newcomers rather than incumbents who may have difficulties in responding successfully and quickly to disruptive innovations.

Burger and Luke (Burger and Luke, 2017) conducted an empirical review analysis that examined the distributed energy business model, and their aim was to support policy makers and regulators. This paper focuses on emerging business models (BMs) in the energy domain, and it aims to understand the structure of entrepreneurship of these BMs. The purpose is to describe an array of business model configurations and to classify them following specific characteristics as well as singular business model patterns.

This article is structured as follows: section two explains the employed methodology. Section three presents the analytical framework that includes the characteristics of Energy Business Models (EBMs) and a synthetic framework for EBM classification. Based on this framework, section four shows the results of the systematic review, presenting the identified EBMs classified as eight patterns. Lastly, section five draws the conclusions.

Methodology

The authors conducted a systematic literature review to accumulate evidence across a body of previous research. The systematic review is a way to address a specific problem by summarizing the existing research and presenting it in one single document (Harden and Thomas, 2005). The aim of a systematic review is not to give answers but to report as accurately as possible what is not known about the research question and the status of present knowledge, in a replicable and organized method (Briner and Denyer, 2012). Following Gough, D.'s (Gough, 2007) methodology, it includes the following phases: identify the research question, define the inclusion and exclusion criteria, describe the search strategy and synthesis.

First, the following research question has been set up to guide the research process: What are the emerging business models in the energy domain and how can they be analysed and classified? This question emerged in response to the increasing need for new business models that accommodate and facilitate the widespread adoption of renewable energy technologies and demand-side management (DSM) systems.

The paper scope is the energy transition focusing on the electricity field; in some cases, papers about non-electrical subjects such as the heating systems for small-scale consumers have been included for their BM interest. Therefore, the chosen articles are in the scope of the renewable energy and DSM areas, excluding articles that provide technical solutions or those that tackle policy issues.

Searches were done through two electronic databases: Scopus and Business Source Complete of EBSCO. The search strategy was to look for the intersection of two groups of items. The first group includes business-oriented keywords: "social enterprise, innovation, value creation, corporate responsibility, business model, entrepreneur and venture". The second group is energy-oriented and had six terms: "energy, power, electricity, distributed generation, renewable and energy service". Searches included the title, abstract and keywords. The intersection of the two previous groups, after excluding oil, fuel, and petroleum-oriented journals and non-English articles, resulted in 981 articles from Scopus and 1370 from EBSCO, including review papers, available book chapters and conference papers. The time window of the research was between 1980 and January 2018. Based on an examination of abstracts, a sum of 229 publications were selected from the two databases. After adding 17 articles from the references and removing the repeated ones, 59 articles were selected that have a significant contribution to the topic of emerging business models for the energy transition.

The most frequently appearing journals are Energy Policy (17), Journal of Cleaner Production (13) and Renewable and Sustainable Energy Reviews (5).

After that, a coding process was initiated in order to combine the individual studies. The focus was on the characteristics of each identified EBM. This step included iterative reading and re-reading cycles. A set of codes, which explain the EBMs attributes, were generated and used to create the final characteristics categories. After this step, we used the activity system theoretical framework of (Zott and Amit, 2010) as a unit of analysis. The analysis consisted of codes related to the design themes such as energy efficiency, product novelty, etc. and codes related to the design elements such as broader stakeholder involvement, new partnerships, servitization and innovative governance schemes.

Finally, the codes were refined and connected to have a synthetic structure. To shape our analysis and reach a high level of abstraction, subcategories were formed combining both the EBM characteristics and the results of analysis of activities system framework. Then through discussion and interaction, the authors closed the remaining gaps and agreed on common patterns.

Analytical framework

Business model

The business model (BM) concept refers to financial and organizational aspects and strategies to reach the markets and the required resources. The term has been intensively used recently, mainly due to changes in communication and distribution channels caused by the Internet.

BM fulfils several functions including articulating the value proposition, identifying a market segment, defining the value chain and value network, estimating the cost and profit structure and formulating the competitive strategy (Chesbrough and Rosenbloom, 2002). Therefore, academics, as well as practitioners, are using the business model to analyse, investigate and describe intra-entrepreneurship activities and new venture launching (Baden-Fuller and Morgan, 2010).

Business models extend the boundaries of the firm to reach the external environment, including partners, suppliers and customers (Zott and Amit, 2010). Johnson and Suskewicz (2009) have emphasized on the role of BM for the whole sector. They showed that in large infrastructure changes, such as the transition from fossil fuels to renewable energy, the BM concept can be a useful tool to support the development of a whole new system instead of focusing on individual technologies. The BMs are defined as integrated parts of a bigger framework that considers the systemic change (Zott, Amit and Massa, 2011). Great technological innovation may fail if insufficient attention is given to the BM design (Teece, 2010). Business models pave the way for the new technologies to take a place in the markets and create value for them; therefore, BMs are considered a construct that mediates the value creation process. It translates the technical inputs into the economic domains of outputs (Chesbrough and Rosenbloom, 2002).

New BMs usually seem unattractive and pose no threat to the incumbent focal firms. Thus, incumbents ignore and fail to respond to these new forms of business as they use different resources, serve specific limited market segments, and have unattractive prices. However, these new activities are acting such as experiments for the advent of innovative BMs (McGrath, 2010).

Business models have been recognized as a locus of innovation (Chesbrough, 2007) and know-how to capture the value is an essential part of BM function (Teece, 2010). BM innovation comes off through three forms: changing the content by adding new activities, changing the structure by linking activities in a novel way, or changing the governance by replacing one or more parties that perform the activities (Zott and Amit, 2010; Amit and Zott, 2012).

Transformation towards sustainable business models (SBM) can be stimulated through the integration of sustainability aspects into firms' BMs (Stubbs and Cocklin, 2008). It includes balancing the environmental as well as social values and adapting specific extensions (Rauter, Jonker and Baumgartner, 2017). Environment and society are recognized as external stakeholders and SBMs include sustainability aspects in the value proposition and value creation (Boons and Lüdeke-Freund, 2013). Shifting to an SBM can be more ambitious through changing organizational perspectives from inside-out to outside-in to create value for common goods (Dyllick and Muff, 2016). Some SBMs such as the product-service system (PSS) or servitization modify radically the way value is created and captured (Hansen, Grosse-Dunker and Reichwald, 2009; Bocken *et al.*, 2014; Yang *et al.*, 2017).

In this paper, the BM conceptualization of Zott and Amit (Zott and Amit, 2010) is used as a framework of analysis that is well-known, rich and has already been employed in the energy sector (Hellström *et al.*, 2015).

Characteristics of new energy business models

This subsection provides a set of attributes to characterize new BMs in the energy sector. These attributes are issued from (36) academic works that address energy business models (EBM). Table 2 presents these academic works and the attributes chosen by each author. Based on these characterizations, the following attributes have been selected to support the descriptions of the EBMs presented in section 4: Servitization intensity, financing and ownership, the customer's role, decentralization level, flexibility degree, and management and control.

Servitization signifies the service-oriented character of the BM and means selling the functionality of the product rather than the product's ownership. This concept is based on replacing the product with a combination of products and services to change the notion of the value from exchanging to utilization (Mont, 2002). A similar meaning is also expressed by the terms "product-service system" (PSS), "eco-efficiency service" or "functional sales". In the energy transition context, servitization is correlated with energy services and energy efficiency, and the notion of having a certain savings percentage on the end-user's energy consumption (Plepys, Heiskanen and Mont, 2015). Variations of energy services have been outlined and ranged from basic services such information and analysis provision to more advanced services such as activities and performance (Kindström and Ottosson, 2016). These variations can be assessed by the servitization intensity, which characterizes the magnitude of services included in a PSS (Tukker, 2004). Energy service activities include energy management, project design, implementation, maintenance, evaluation and energy and equipment supply while performance refers to savings guarantees, and its remuneration is directly tied to the energy savings achieved (Bertoldi, Hinnells and Rezessy, 2006). Furthermore, energy service contracting allows the service provider to sell service provisions such as lighting levels, room temperature, humidity and comfort (Sorrell, 2005). Recently, servitization has been used to refer to the transformation of the energy utility business model to a service-oriented BM to meet energy transition challenges (Helms, 2016), demand-side management (Helms, Loock and Bohnsack, 2016) and distributed generation (Boston Consulting Group, 2010; Överholm, 2017). Energy utility servitization, defined as the development of BM from simple commodity suppliers to comprehensive energy solutions that include consulting, installation, financing, maintenance and warranties (Richter, 2012), allows energy utility to decouple energy volume sales from revenue. Solar service firms are new market actors who sell the function of the photovoltaic (PV) solar panel systems rather than the solar panel (Överholm, 2017). Two main offers are developed, the leasing and power purchase agreements (PPA) (Wainstein and Bumpus, 2016). Frequently, energy BMs with a high servitization intensity have the potential to reduce the environmental impacts of the energy sector (Hannon, Foxon and Gale, 2013).

Financing and ownership have been the locus of BM analysis (Frantzis *et al.*, 2008; Okkonen and Suhonen, 2010; Kanda, Sakao and Hjelm, 2016). Ownership can be organized in different ways such as privately, publicly or private-public partnerships; nevertheless, three main ownership models have been noted in the energy domain: consumer's ownership, collective community ownership and service-based with company ownership (Walker and Cass, 2007; Juntunen and Hyysalo, 2015; Zhang, 2016).

Renewable energy resources ownership may have an influence on the grid capacity and thus on grid stability and energy supply security. The decisions that owners of renewables make may contribute to increasing or decreasing grid balance. Frantzis et al. (Frantzis *et al.*, 2008) have distinguished between customer or/and third-party ownership and utility ownership. The main difference is that in the latter, the energy utility has the full authority to manage and control the renewables production, consequently maintaining grid balance, while in the former, the prosumers have the choice to accept or refuse to contribute to grid balance activities (e.g., demand response). Community ownership is often considered as a source of income that can be controlled locally and therefore, these kind of investments are more likely to be accepted socially (Walker, 2008). The main motivation for developing local supply ownership is to avoid value leakage out of the local economy (Hall and Roelich, 2016).

Financing renewable energy technology is highlighted as a crucial factor for both micro-generation or for large-scale renewable energy technologies. In the former, PV upfront cost is often described as a barrier that prevents customers from having a clean energy resource and hence outsourcing financing to a third-party in order to remove this barrier (Engelken *et al.*, 2016). In the latter, financing has also been addressed as a barrier because of the long-term investment in the infrastructure assets (Kanda, Sakao and Hjelm, 2016) and the success and failure of the financial configuration is often dependent on the institutional support (Bolton and Hannon, 2016). Alternative financing sources for renewable energy investments emerge from citizen participation in energy cooperatives (Yildiz, 2014), where the financial risk can be mitigated due to local authority investment (Cato *et al.*, 2008). A similar mechanism for collectively fundraising for renewables is through crowdfunding platforms (Vasileiadou, Huijben and Raven, 2016).

The next attribute is the c***ustomer's role***. In recent renewable and DSM systems, the relationship with customers has been modified. These changes include the intensification of the customer engagement, delivering new services, providing real-time information and the installation of two-way communication channels (Tayal and Rauland, 2017). The consumer's behaviour, attitudes, tastes and needs are critical factors for the proper running of decentralized systems (Burger and Weinmann, 2016). The user involvement and interaction within the firms occurs not only at the marketing phase but at the design and use phases as well (Tolkamp *et al.*, 2018). Furthermore, multiple roles for consumers are described in the literature: "actives" consumers who self-consume green electricity; customers as "financial investors" in renewables; "service users" demanding light, heat, etc. instead of an energy commodity; "local beneficiaries"; project "supporters"; " protestors" and "activists"; "technology hosts"; and "producers" (Walker and Cass, 2007). The customer's role is central in order to reduce the intervention cost in the DSM systems that is defined as the cost of exploring heterogeneous and specific consumption patterns and compensating consumers for participating in demand response programmes (Helms, Loock and Bohnsack, 2016).

Energy systems can be designed by different ***decentralization levels***. The smaller production capacity of renewables and their distributed nature create a new decentralized energy market that requires different revenue models. This characteristic can provide solutions for each consumer separately, which implies high cost in comparison with one-size-fits-all solutions. It includes a strategic shift from big to small, from commodity to service, from wholesales to a customer-orientated strategy and from long-term planning to a more flexible planning (Burger and Weinmann, 2016). Developing local projects based on distributed generation creates local jobs and income, improves social fairness and equity, reduces carbon emissions, enhances air quality and reduces fossil fuel dependence (Hall and Roelich, 2016). The locally grounded, collectively shared, participatory and politically supported community renewable would lead to a high level of participation (Süsser, Döring and Ratter, 2017). In the case of local entrepreneurship, the emphasis is on the importance of who is participating and for whom participation is performed. Often local entrepreneur assemblies are based on mutual trust (Süsser, Döring and Ratter, 2017). Decentralization refers to the position on the distribution network and the transfer of energy from the production site to the consumption site, in which the ownership of this network and proximity between production and consumption play a critical role in determining the business model (Walker and Cass, 2007; Juntunen and Hyysalo, 2015).

Flexibility degree refers to the "ability of power systems to utilize their resources to manage net load variation and generation outage, over various time horizons", and net load is defined as load minus supply from intermittent resources, such as wind and solar (Boscán and Poudineh, 2016). Flexibility can be stimulated either from consumption's valuables or from generation's valuables by coupling them with timing service (Helms, Loock and Bohnsack, 2016). The decentralized generation is not just developing sources of renewable energy but also a way of local balancing. The end-user flexibility and the active management may be used to strengthen the stability of the grid (Gordijn and Akkermans, 2007; Schleicher-Tappeser, 2012). Trading flexibility services are important to have a reliable power system (Boscán and Luis, 2016). Flexibility has three main functions, which affect three different electricity market users (Boscán and Luis, 2016). First, the "integration of intermittent resources", which has an influence on market balancing and is managed by a transmission system operator (TSO). Second, the "congestion management" in the electricity network, where a distributed system operator (DSO) captures flexibility benefits and benefits from low congestion. Third, market players such as aggregators, suppliers and balancing responsible parties are concerned about obtaining cost-efficient outcomes by leveraging "portfolio optimization".

Management and control are worth pointing out in this context, as who takes the responsibility of maintaining and keeping the hardware working is of great importance (Kanda, Sakao and Hjelm, 2016). Management consists of three pillars: operation, control and governance. Many factors affect this characteristic such as the proximity of the technology to the consumption's site (Juntunen and Hyysalo, 2015), as well as the contract, the partnership and the legal form (Walker and Cass, 2007; Okkonen and Suhonen, 2010; Bolton and Hannon, 2016). It should be noted that the operation and control are key activities that aim also to optimize grid balance and electricity trading service and to provide maintenance to the co-owned infrastructure (Facchinetti and Sulzer, 2016). Operation and control are prerequisites in order to handle the fluctuation of renewable energy production and grid balance (Frantzis *et al.*, 2008; Helms, Loock and Bohnsack, 2016).

Energy communities are entities whose members themselves govern and manage the renewable projects. The governing model is subject to who runs, influences and is involved in developing these communities, members' commitments and their shared vision (Walker and Devine-Wright, 2008; Van Der Schoor and Scholtens, 2015).

Results and discussion

Based on the literature review and activity system conceptualization (Zott and Amit, 2010), this section outlines a set of energy business models. Each business model has been analysed separately using characteristics defined in subsection 3.2. Then, they have been classified according to two parameters. First, the source of value: novelty, lock-in, complementarities and efficiency; and second, regarding how the value is created: content, structure and governance (Amit and Zott, 2001). As a result, the classified EBMs have been clustered forming eight patterns presented in Fig. 2. For simplicity and conceptual clarity, the clustering shows the independency of the patterns, but in some cases, there can be an overlapping between two or more patterns. The following subsections analyse each pattern and the EBMs within each pattern, following the four BM themes.

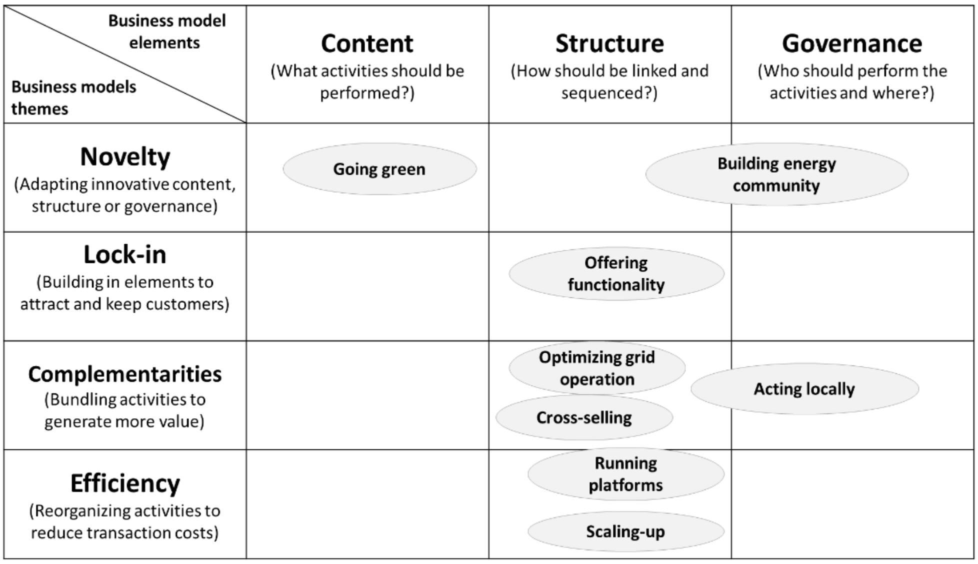

Fig. 2. Energy Business Model patterns

Going Green

In this pattern, innovation occurs mainly by replacing the energy fossil fuel with renewable energy resources, and, therefore, the innovation is mainly rooted in the content of the BM rather than in the structure or in the governance. Two energy business models are identified within this pattern: the "utility-side renewable energy" and the "prosumer" (Richter, 2013).

The "prosumer" EBM has been identified mainly in small PV systems, which are owned and hosted by the customer. The customers are driven by governmental incentives such as income tax reductions during the first years and the feed-in tariff. The incentives secure income and eliminate the price risks (Strupeit and Palm, 2016; Zhang, 2016). Scholars have different terms for this EBM such as "Local producer", "Zero Generation PV" and "customer-owned" (Gordijn and Akkermans, 2007; Frantzis *et al.*, 2008; Huijben and Verbong, 2013). The customer creates the value through small-scale owned distributed generation. In this EBM, the installer firm plays a key role in customer adoption of the PV systems. Usually, installers are local firms, which depend on the network of producers and wholesalers to obtain technical knowledge on these new systems (Karakaya, Nuur and Hidalgo, 2016). However, in some regions these local firms are facing challenges such as diminishing feed-in tariffs for PV, declining adaptation rates and decreasing installation profitability (Karakaya, Nuur and Hidalgo, 2016). In this EBM, the customer partly replaces the fossil fuel utility-based electricity with their own renewable energy resource and becomes a prosumer.

Building energy communities

Four EBMs have been identified within this pattern: utility-sponsored communities (USCs), special-purpose communities, energy cooperatives and local white labels. USCSs target new market segments including multi-family homes and residential rooftops that are not suitable for hosting on-site PV systems. It has been found that USCS is an opportunity for utilities in the U.S., which face shrinking revenue on expenses of residential solar PV (Funkhouser *et al.*, 2015). The second identified EBM is the special purpose entity (SPE), which is based on investor-owned companies with strong policy incentives. The main motivation of SPEs is to profit from investment tax credits (ITC) (Coughlin *et al.*, 2011). In this BM, the members have to raise the capital, negotiate contracts with owners and the site host, set up legal and financial processes for sharing benefits and manage the operation of the business (Coughlin et al., 2011; Funkhouser et al., 2015).

The third EBM identified within this pattern is the energy cooperative model. These cooperatives conduct business activities along the energy value chain including generation, distribution and trading. Moreover, this membership model can lead to active participation of consumers (Yildiz *et al.*, 2015). In the energy cooperatives, citizens are customers as well as key partners; they take part of the governance and finance part of the capital to generate local and green electricity (Küller, Dorsch and Korsakas, 2015). However, the traditional BM elements and structure, which are business economics oriented, has been found unsuitable for representing the energy cooperative BMs (Dilger, Konter and Voigt, 2017).

Lastly, the local white label EBM has been identified within this pattern. This EBM refers to an independent supplier who is working on local scale linking local authority, community groups and other actors. The local white label has the potential to link local supplier with a local customer, thus allocating cost of local generation to local customers (Hall and Roelich, 2016).

Offering functionality

In this pattern, energy service providers offer energy efficiency measures or renewable energy systems through a solution not based on product ownership transfer. The value creation includes services such as financing, installation and maintenance. Consumers' roles are passive and similar to the conventional role.

Three EBMs have been identified within this pattern: the energy service company (ESCO), the third-party BM and the customer-side renewable. In these EBMs, the financial partners are crucial (Wainstein and Bumpus, 2016), and the combination of products and services is built on alliances between manufacturers, installers, and insurance firms and can lead to great potential to improve sustainability (Överholm, 2017).

Energy service companies provide energy services that reduce energy consumption using more efficient energy systems. These services include financing, controlling and maintaining the equipment. ESCOs have lower cost compared with energy utilities, assume most of the financial and technical risk, provide bespoke and holistic energy services and create environmental and social benefits. Moreover, the relationship with customers is close and long-term (Hannon, Foxon and Gale, 2013). ESCOs have a unique financial model; however, it is regarded as time consuming because of the investment procedures and the long payback period, and, furthermore, consumers have a weak knowledge of ESCO offerings (Pätäri and Sinkkonen, 2014).

The third-party EBM is often linked to the PV technology and therefore is often cited in the literature as the third-party PV BM. The PV systems are installed on the roofs of the customers' houses, and customers pay a fixed price per kWh of the direct use of the PV system for a long period (more or less 20 years) thanks to the power purchase agreement (PPA). In other cases, customers are involved in a leasing contract and pay a fixed amount per month for the usage of the PV system (Huijben and Verbong, 2013; Zhang, 2016). The third-parties control and own the PV system, bearing the financial risk and reducing complexity for the consumers. Other stakeholders such as energy utilities assume the role of a facilitator for PV market diffusion in this case (Frantzis *et al.*, 2008). Customers have an immediate reduction of up to 10-20%, a predictable cost of electricity over 20 years and a lower upfront cost. Moreover, the learning and scale effect enable the firm to lower the transaction cost associated with incentives, grid connection, permits and installations (Strupeit and Palm, 2016). The application of this EBM by energy utilities has been described by Richter (2013) as "customer-side renewable energy".

Optimizing grid operations

In this pattern, three EBMs are presented: demand-response, virtual power plant, and active management of distribution networks.

The demand response EBM looks for mechanisms to change end-users' usual consumption shapes. This modification is especially interesting when facing high wholesale prices or when system reliability is jeopardized (Albadi and El-Saadany, 2008).

The DRP can create value for generation stakeholders by creating a desirable load profile, which increases their operation efficiency. DRP can also offer services to transmission and distribution actors by reducing consumption in congested zones, thus helping to delay or reduce investment in the infrastructure (Poudineh and Jamasb, 2014). Concerning the retailing stakeholders, the DRP uses its competences to modify the consumption shape of a retailer to reduce its procurement costs. Lastly, DRP creates value for load stakeholders by shifting the electricity load when the kWh prices are high (Behrangrad, 2015).

The second BM is the "virtual power plant" (VPP); herein, the provider aggregates a combination of high numbers of small-scale generation units (e.g., CHP) and renewable energy resources in order to generate a sufficient capacity, enabling producers to participate in the energy market and gain fees from their flexibility, often complemented with consumption management (Helms, Loock and Bohnsack, 2016).

The share of renewable energy resources and distributed generations, which are connected to the grid, is growing. This concept is defined as a system in place to control a combination of distributed resources, in which DSOs have the possibility of managing the electricity flow and generators take some degree of responsibility for system support through a connection agreement (D'Adamo, Jupe and Abbey, 2009). The DSO is responsible for the distribution network operation. In this EBM, the DSO provides voltage management services to the renewable energy resources, and the generators profit from this service by maximizing their connected capacity and generated electricity (Gordijn and Akkermans, 2007). The aggregator can also provide this service by aggregating and limiting commercial and industrial consumers' maximum power consumptions during congestion periods. This service maintains the voltage within the DSO network capacity and prevents voltage variation risk (Rahnama *et al.*, 2017).

Lastly, an innovative activity that is currently being developed includes the installation of energy storage systems, which is a key activity to balance the intermittency of renewable energies. Based on these activities, innovative BMs have been developed, which has allowed early stage companies to make a place in the energy value chain (Behrangrad, 2015; Müller and Welpe, 2018).

Acting locally

In this pattern, the complementary service of demand response is organized locally in order to create and capture the value of load balancing locally. DR value proposition is related to cheaper power use, matching local generation with local loads and systems benefits to infrastructure providers (Hall and Roelich, 2016). Three EBMs are proposed, first the e-balance EBM, then, the local pool and sleeve EBM and lastly, the Energy hub.

The e-balance EBM aims at locally balancing consumption and production in an intelligent and effective manner in order to enhance the reliability and efficiency of the low/medium voltage energy grid levels; it acts as a platform based on ICT and citizens' behaviour (Matusiak, Piotrowski and Melo, 2015).

Finally, the Energy Hub EBM refers to a local energy system that mediates multi energy carriers (electricity, thermal and chemical energies) that optimize energy management and integrate energy conversion and storage units. It primarily guarantees energy supply and demand match through internal flexibility and energy market participation (Facchinetti and Sulzer, 2016).

Scaling-up

In this pattern, the firms generate economies of scale by aggregating supply, as in the case of the first EBM, the network model of a large company, which is taken from the heat supply sector. In the second EBM, economies of scale are achieved by aggregating demand, as in the collective buying of PV solar panel systems.

In the first BM, a network model of a large company, the provider's value creation enables a low-cost unit of heat supply due to its several operation units. Economies of scale in the fuel supply (e.g., biofuel, wood chips, etc.) are the core of the value creation. Customers such as municipalities can lease the required infrastructure such as the heat plant and the distribution network to the provider, which is also operating the heat production. While the major benefit is the cost efficiency, the supply of foreign fuel might have an impact on the local and regional economics (Okkonen and Suhonen, 2010).

In the "collective buying", the second EBM, an organization, provides a service of buying, installing, and maintaining the PV system on the customer sites or it only arranges the installations. In both cases, the subscribers benefit from availability of information such as selection of suppliers, price bargaining, insurance, etc. (Huijben and Verbong, 2013).

Running platforms

Digital and advanced technologies are increasingly transforming the electricity value chain, transforming the way electricity firms create, deliver and capture value (Shomali and Pinkse, 2016). In this pattern efficiency gains are generated by making transactions more transparent and fast, simplifying the processes and increasing the availability of information. The emergence of online platforms in the energy sector is driven by the increased volatility of renewable generation, end-user new role complexity and the introduction of ICT (Weiller and Pollitt, 2014).

The first EBM, the "peer-to-peer", consists of a software platform that plays an intermediate role between commercial consumers and the distributed generation where consumers can choose their energy mix and compare the different tariffs (Hall and Roelich, 2016).

In the second EBM, the "crowdfunding for renewable energy", is described as an organizational innovation form used by people who are networked and pooled. The main purpose is to raise funds and finance renewable energy projects collectively and thus to scale up renewable energy projects and transform the energy and the financial regimes (Vasileiadou, Huijben and Raven, 2016).

Lastly, the electricity balancing service platform EBM is a matching platform between suppliers who cannot predict their renewable energy generation and consumers who participate in the energy demand side management and are vulnerable to real-time electricity price volatility. It aims at providing demand response service to electricity suppliers and reducing consumers' bills by optimizing and managing the household electricity (Weiller and Pollitt, 2014).

Conclusion

The EBM framework that is suggested in this paper fills an important gap in the literature on energy business models with regard to fostering energy transitions through business model innovation. Although many scholars have studied business models in the energy sector, little attention is paid to providing an exhaustive framework on business model levels and innovation stimulation. This paper presents a BM framework from activity systems by integrating a set of energy characteristics that were issued from a literature review. Based on this framework, 22 different EBMs have been presented clustered in eight patterns.

The results show that diffusion and commercialization of distributed renewable energy and demand-side management services are fostered by innovation in the business model content, structure and governance. Innovative content EBM refers to the replacement of fossil fuel with sustainable energy resources. Innovative structure EBMs are driven by collective initiatives, joint value creation, cross-selling, intermediate platforms and product-service systems. Innovative governance EBMs are driven by economic, environmental and social values and democratic management, transparency, local value creation and the engagement of public actors.

Our main contribution has been to emphasize the similarities and differences between the emerging business models and to point out that novel business models are emerging in the energy market driven by different values and employing different business model logics. The motivation beyond this paper supports the belief that the shift from unsustainable to sustainable energy systems will require a deep understating of how the values are created in each of the defined patterns.

The same value proposition can be created with different patterns such as in the case of solar power generation, which is employed in going green, offering functionality and building community.

Furthermore, new activities in the energy value chain that have been identified in the literature can be based on one or several EBMs presented in this paper. Some of the presented EMBs are more likely to be combined as they offer interesting synergies. This is the case for example of activities where the consumer becomes a prosumer, not only owning renewable energy systems but also being an actor in the demand response systems. This combination offers interesting possibilities for EBMs such as the virtual power plant.

Lastly, the proposed framework can be used for ideating new business models, which is a task that newcomers to the energy sector are looking for and face. Since newcomers are driven by technologies rather than by business models, the proposed patterns assist managers in innovating by combining several EBMs or patterns, by changing the characteristics of specific EBMs, by removing or adding design themes, or by bringing new configurations into the design elements. Furthermore, our framework can be used as a starting point for analysis and development of existing EBMs and for reducing complexity and drawing a comparison between different potential alternative EBMs within specific patterns or even between the distinct patterns. Finally, the paper provides insights on how to design new business models for entrepreneurs who seek to build non-existent business models.

The EBM framework can be used to invent new business models by manipulating and exploring the different possibilities of employing one or more of the proposed characteristics, adopting specific patterns, or by changing the design elements or selecting different design themes.

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