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Collaboration Mechanisms for Sustainable Value Creation in the Renewable Energy Industry: A systematic Literature Review

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To my beloved family, Papito, Mamita and Mattol,

always together in time, space and eternity.

To the love of my life and best friend, Hugo,

may this ending be the beginning of the best time of our lives.

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Content

List of Tables

List of Figures

List of Abbreviations

BEV: Battery Electric Vehicles

BP: Best practices

BoP: Bottom of the Pyramid

BM: Business model

BMC: Business Model Canvas

BMI: Business Model Innovation

CHP: Combined Heat and Power

CRE: Community Renewable Energy

CSV: Creating Shared Value

DSR: Demand-side Response

DRE: Distributed Renewable Energy

DSO: Distribution System Operator

EV: Electric Vehicles EV

ESCO: Energy Sevice Company

ICT: Information and Communication Technologies

ICES: Integrated Community Energy System

IoT: Internet of Things

M&A : Merger and Acquisition

PV: Photovoltaic

RE: Renewable energy

RES: Renewable energy source

SG: Smar Grid

SBM: Sustainable business models

SLR: Systematic Literature Review

TSO: Transmission System Operator

TBL: Triple Bottom Line

Abstract

The energy sector has been undergoing major changes in the last couple of decades. The three most relevant drivers for this situation are energy market liberalization, the advent of renewable energies and digitalization of the sector. The conjunction if these three phenomena has given rise to new participants in the market as well as new sets of relationships among them and incumbents. This evolution has derived in the emergence of new business models in the energy sector.

The business model (BM) concept has gained relevance among scholars in different fields; consequently, several theories and definitions have been developed around it. One of the most widespread describes BM as a series of strategic activities that define the way in which a company creates, captures and delivers value. The study of BM has been traditionally performed from a single-firm perspective, in spite of the fact that many authors have acknowledged that the operationalization of a BM, even if centred on a focal firm, is not limited by it; on the contrary, value creation is a boundary-spanning phenomenon, for which a system-level approach should be prioritised.

The need of a system perspective is emphasized when firms aim at developing sustainable value, since one of the key aspects of sustainable business models (SBM) is the collaboration and alliances with other stakeholders, including the user. Thus, it is of paramount importance that the process of value creation for sustainability is understood as a boundary-spanning phenomenon.

However, most of the research on BM topics is carried out regarding performance implications for a single firm; for that reason, a research gap remains on changes in SBMs resulting from collaborations among actors. Under this statement, this work attempts to present an analysis of **value creation in interorganizational relationships as a result of the adoption of Sustainable Business Models by a focal firm in the Renewable Energy Sector.** The chosen methodology is *Systematic Literature Review (SLR), and* SBM are considered as a unit of analysis; the different levels of analysis proposed

by researchers are broken down ex-ante and a typology of mechanisms that enable collaboration are proposed from the SLR.

The three pre-defined levels of analysis are *company level, value chain level and system level,* while the mechanisms that enable collaborations are also found to be three: *basic synergies*, *new functions* and *new actor.* Also, nine dimensions and ten sub-dimensions are proposed. The dimensions found as basic synergies are *purchasing, exploitation of a current asset or capability with a new purpose, extension of current activities or services,* and *co-planning of activities*; as new functions are *new structure, new capabilities* and *new organizational model*; and, as new actor the two dimensions are *spin-off* and *start-up.*

A relevant finding is that the dimensions proposed for the framework are consistent regardless of the level perspective adopted in each study. For that reason, it is reasonable to state that the level of analysis taken by researchers does not have a relation to the collaboration mechanisms that enable sustainable value creation.

According to the evaluation of the BM proposed in the papers, the mechanism that is mostly used to enable collaboration between a focal firm and other actors is given by *new functions*, i.e. the focal company adapts to the collaboration ecosystem by changing their structure, acquiring new capabilities or modifying their organizational model.

A series of practical implications are presented, as well as some propositions for future research.

I. Introduction

i. Context of the Energy Sector

The energy market is currently under a process of deep transformation (Kotilainen, Sommarberg, Järventausta, & Aalto, 2016). It used to be considered as a stable sector due to aspects such as well-known players, and consistent customer relationships and business models (Leisen, Steffen, & Weber, 2019a). However, this regularity has been threatened by three events that have urged the industry to redefine itself: market liberalization (Mir Mohammadi Kooshknow & Davis, 2018a), the breakthrough of renewable energy (Dehdashti, 2019) and digitalization (Leisen et al., 2019a).

These three events are the result of a combination of factors such as Climate Change and the resulting greener regulatory requirements in all industries, advent of generation alternatives which have changed the construction and operation of power plants, new transmission and distribution technologies, revolution of Information and Communication Technologies (ICT) as well as of Internet of Things (IoT), among others. These changes are briefly described in the following paragraphs:

Before market liberalization, the energy sector consisted mainly of monopolistic structures (Gsodam, Rauter, & Baumgartner, 2015) that integrated vertically the activities of generation, transmission and distribution. The liberalization strategy allowed the unbundling of electricity generation and grid operation activities (Leisen et al., 2019a) by clearly distinguishing that these two parts of the industry should work through a different logic: while the network operation remained as a monopoly, the generation and supply should be opened to competition (European Commission, 2012c). This new scheme was introduced with the main objective of increasing the quality of electricity services at a more affordable price (Pereira, Specht, Silva, & Madlener, 2018a), and it also had the effect of an increased interest and involvement in the market of new private actors (Engelken, Römer, Drescher, Welpe, & Picot, 2016).

On the other hand, the increase in energy generation from renewable energy sources (RES), was motivated from the need to drastically reduce carbon emission in order to mitigate the risks related to climate change (Tronchin, Manfren, & Nastasi, 2018), which include melting of the polar ice shields, sea rising and extreme weather events, among other localized phenomena (European Commission, 2012a). According to the Intergovernmental Panel on Climate Change, a permanent scientific observatory by the UN, human activities have already caused approximately 1°C of global warming, and this increase is likely to reach 1.5°C between 2030 and 2052 if the grow rate continues unchanged (IPCC, 2018).

This phenomenon has been attracting attention from the scientists for many years, but it was not until virtually recently that it has caused the political community and general society to be more involved and start making efforts to prevent global temperature from continuing to rise. A result of these efforts was the release and signing of the Paris Agreement in 2015. Its central objective is to intensify global actions against the threat of climate change, specifically, by keeping a global temperature rise well below 2°C (United Nations, 2018); it is estimated that, in order to achieve the goal, greenhouse gases must be reduced by at least 75% by 2050 compared to 1990 levels (European Commission, 2018) . Moreover, this percentage increases for the case of developed countries, since they need to reduce their emissions by at least 80% for counterbalancing the increasing share of developed countries (European Commission, 2019).

Several specific policies have been implemented to operationalize the Paris Agreement's goal; one of them is the European 2020 package, which was officially introduced in 2009 and that sets three key targets: i) 20% cut in greenhouse gas emissions (from 1990 levels); ii) consuming 20% of EU energy from renewables; and, iii) 20% improvement in energy efficiency (European Commission, 2012b). This can now be considered a successful strategy since two objectives have been reached: i) Data from Member States indicate that the EU's total emissions decreased by 2.0 % in 2018, for an overall reduction of 23.2 % below 1990 levels; ii) The target of increasing the share of renewables in final energy consumption is “within reach”, as the EEA estimates that the share of renewables was 18.0 % in 2018; and, iii) However, the last target has not been as successful since the final energy consumption — energy consumed by end users — in the EU in 2018 grew by 0.1 %. (European Environment Agency, 2019).

The last event that has had a major impact on the energy sector is Digitalization. Over the last decades, digital technologies have developed to form part of our daily environment; their presence reaches almost every aspect of our life. In general, they are set to make systems around the world more connected, intelligent, efficient, reliable and sustainable (iea, 2017).

The trend towards greater digitalisation of energy has been enabled by a higher connectivity of the actors and the possibilities of data gathering and analytics. These include increasing volumes of data, due to the declining cost of sensors and data storage; rapid progress in advanced analytics such as machine learning; greater connectivity of people and devices; faster and cheaper data transmission. The combined application of these elements can greatly increase the lifetime, efficiency and utilisation of energy infrastructure and can reduce costs (Pineda, 2018).

Moreover, digital technologies also allow devices across the grid to communicate and provide data useful for grid management and operation. Smart meters, new smart/IoT sensors, network remote control and automation systems, and digital platforms that focus on optimization and aggregation, allow for real-time operation of the network and its connected resources and collect network data to improve situational awareness and utility services (Martin, Starace, & Tricoire, 2017). Additionally, new technologies are also expanding opportunities and prompting experiments with new business models (Smith, 2019).

ii. Business Models

The business model (BM) concept started to gain attention from researchers in the mid-1990s, apparently, driven by the advent of the Internet, and it has become increasingly studied in time (Zott, Amit, & Massa, 2011). Throughout the years, the conceptualization has had many interpretations, such as a statement, a description, an architecture, a model, a structural template, a framework and a pattern among others (Zott et al., 2011). Additionally, this concept has become relevant in the fields technology and innovation management, strategy, environmental sustainability and social entrepreneurship to name a few (Massa, Tucci, & Afuah, 2017).

Although there are several definitions of BM in the literature (Evans et al., 2017), many authors agree that **a BM consists of a series of strategic activities that define the way in which a company creates, captures and delivers value** (N. M. P. Bocken, Short, Rana, & Evans, 2014; Evans et al., 2017; Osterwalder, Pigneur, & Tucci, 2005; Rossignoli & Lionzo, 2018; Teece, 2010; Urbinati, Chiaroni, & Chiesa, 2017; Zott et al., 2011).

For Zott et al., (2011), this conceptualization focuses on the *strategic issues* of a firm and is related to concepts such as competitive advantage and firm performance. A BM represents a source of competitive advantage in the sense that, the context in which a company displays its it, is a sort of arena where firms compete precisely through their BM (Zott et al., 2011). On the other hand, its influence on a firm’s performance comes mainly from the set of components that determine the firm’s profitability (Zott et al., 2011).

The implications of the study of BM from the perspective of strategy go even further. Traditional theories of strategy assume value creation as a supply-side phenomenon, i.e. that is created exclusively by producers, and limit competitive advantage to a single source (Massa et al., 2017). However, more recent theories have challenged this view, stating that value can be created in the supply and demand-side of a value chain, which means that customers and other related members of an ecosystem can participate (Massa et al., 2017).

This change of perspective has also impacted how research on BM is carried out. Traditionally, the analysis of business models has been made from a single-firm perspective (Hellström, Tsvetkova, Gustafsson, & Wikström, 2015), even if industry transformation and system changes tend to require the joint efforts of several companies or the change of more than one company's business model.

Consequently, many authors have now acknowledged that the operationalization of a BM, even if centred on a focal firm, is not limited by it; on the contrary, its boundaries seem to overpass the focus company, emphasizing a system-level approach (Zott et al., 2011).

In general, there are two major parts to each business model: The set of activities that the firm performs, and the outcomes of performing these activities; being the outcomes determined by when the firm performs those activities, how it performs them, who performs them, and the resources/ capabilities that it chooses to use (Massa et al., 2017). The definition of these activities, resources and capabilities can remain within the firm or surpass its limits through cooperation with partners, suppliers or customers.

In this sense, some authors have pointed out that a broader and more complete perspective for studying business models is achieved if the analysis is made considering the whole system, i.e. all its elements and their interactions (Evans et al., 2017). Accordingly, Zott & Amit, (2010), state that it is the set of activities performed as a system that enable a firm to create value, being the system "the focal firm, its partners, vendors or customers, etc.". For that reason, it is not surprising that many BM conceptualizations focus on the notion of activities or activity systems (Zott et al., 2011).

In practical terms, value creation through BM requires a series of activities performed by multiple actors that are interconnected among them, i.e. **an activity system** that, despite being firm-centred, spans its boundaries (Zott et al., 2011). The process of value creation is, therefore, not strictly linear from a firm to its customers.

Firms create relationships with other individuals, groups or organizations, and form networks with the objective to identify, and act on business opportunities (Karlsson, Hoveskog, Halila, & Mattsson, 2019). Moreover, some authors suggest that firms should aim at performing successfully as part of a network rather than individually (Evans et al., 2017), since, in that way, they also succeed in producing sustainable value (Karlsson et al., 2019).

Therefore, novel forms of value creation mechanisms are networked, meaning that value is created in conjunction by a firm and a group of its partners. This view has been particularly addressed by scholars in research regarding BM and value creation in networked markets (Zott et al., 2011).

The introduction of the concept of value into Business Networks has established the concept of Value Networks (Evans et al., 2017), which can be understood as set of roles and interactions among organizations with different needs that engage in value exchanges. Evans et al., (2017), suggest that the integration of sustainability at network level leads to the achievement of common and individual goals for its members and could enable innovations towards new sustainable business models (SBM).

Consequently, a network approach, in a sustainable context, must include all stakeholders, as it becomes beneficial not only for the firm and its customers (Karlsson et al., 2019; Rossignoli & Lionzo, 2018), but also other stakeholders (Specht & Madlener, 2019). This holistic perspective focuses on value co-creation because it can capture aspects of the system more easily, which is the main reason for its success (Karlsson et al., 2019). It is, thus, important that a BM from a network approach, embraces the system dynamics of the society and the environment it performs in.

iii. Business Models for Sustainability

Describing sustainability is describing a complex phenomenon, particularly in the energy sector (Rossignoli & Lionzo, 2018).

Concerns for sustainability are increasing in many industries; as environmental and social issues gain relevance, they cause market shifts and industrial scenarios to become highly dynamic (Nair & Paulose, 2014). In this situation, existent business models need to undergo modifications for their proper adaptation; this includes changes of existing BM and development of new ones (Schaltegger, Lüdeke-Freund, & Hansen, 2012).

Business model innovations for sustainability are defined as: "Innovations that create significant positive and/or significantly reduced negative impacts for the environment and/or society, through changes in the way the organization and its value-network create, deliver value and capture value (i.e. create economic value) or change their value propositions." (N. M. P. Bocken et al., 2014).

Business model for innovation can be understood as finding new methods for producing products or providing services or creating greater value from existing products or services, rather than aiming at creating new products or services. At the corporate level, a business model for innovation may refer to an innovative way for a company to adapt to changes. (Chen, Chen, & Shen, 2020)

It is important to state that this definition does not imply that these innovations should be achieved through technology; on the contrary, changes in the conceptualization of business models should be made by building partnerships (Nair & Paulose, 2014) regarding exchanges and relations with stakeholders (Evans et al., 2017). By adopting a sustainable business model (SBM), firms also aim at reducing costs, waste and their negative environmental impacts, while creating value with their products and services (Nair & Paulose, 2014).

For that reason, when it comes to SBM creation, many authors refer that one of the key aspects is the collaboration and alliances with other stakeholders, including the user, for value creation (N. M. P. Bocken et al., 2014; Brehmer, Podoynitsyna, & Langerak, 2018; Comin et al., 2019; Rohrbeck, Konnertz, & Knab, 2013; Rossignoli & Lionzo, 2018); this is particularly important in early stages, so that potential consequences of the proposed activities can be identified (Karlsson et al., 2019) .

Collaborative activities for SBM are not only suggested, but necessary for efficient sustainability management. Seuring & Gold, (2013) state that sustainability can only be effectively integrated in a firm if its actions exceed the organizational boundaries. Hellström et al., (2015) argue that the links with other actors need to be based on their BM rather than focusing only on their organisation or other internal factors.

These relationships are a consequence of a highly interconnected world, where identifying and overcoming challenges is more difficult for individual firms; in fact, the actual global agenda pushes corporations towards the awareness that sustainability challenges cannot be addressed by one actor alone (Seuring & Gold, 2013). It is, then, evident that SBM can only be addressed in joint efforts, and they need to be comprehended from a system perspective (Seuring & Gold, 2013).

A system perspective considers the ecosystem of a focal firm and how it actively creates links between itself and other companies (Hellström et al., 2015). These collaborations provide value for customers, since in a well-organized inter-related set of activities, every member adds value to products and services (Seuring & Gold, 2013), which is particularly appreciated when there is no evident differentiation of the additions among the various actors involved. On that matter, researchers such as Hellström et al., (2015), emphasize the fact that, essentially, value is co-created.

On the whole, SBM can be seen as the representation of an organization's sustainable value exchange with its stakeholders in the system, supported by the analysis, management and communication of its sustainable value proposition, sustainable value creation and delivery system plus the value captured by the organization itself and other stakeholders (Khripko, Morioka, Evans, Hesselbach, & de Carvalho, 2017a). Thus, it is of paramount importance that the process of value creation for sustainability is understood as a boundary-spanning phenomenon.

Business Models in the Energy Sector

From what has been previously stated, the development of new Business Models (BM) is a complex process (Evans et al., 2017) and has many variables. In the particular case of the Energy Industry, one of them appears to be the increasing number of actors participating in the market, as well as the fact that, with the addition of new participants, their functions in the market and the way in which they interact with each other has also changed.

According to Christensen, Wells, & Cipcigan, (2012), new business models typically emerge in contexts when new ways of doing business become possible. These contexts can be given by technological innovations, economic distress -which causes a firm to lose their competitive power-, or regulatory conditions that push businesses to adapt their business models (Christensen et al., 2012). From the context in the previous section, it is clear that the Energy Market falls directly into two of these three conditions; thus, predictably, there has been an emergence of new business models in the sector (Leisen, Steffen, & Weber, 2019b).

The liberalization of the energy sector promoted the creation of new business models due to the unbundling of the systems' functions (i.e. generation, transmission and distribution) and the increasing involvement of private actors, as opposed to the previous trend of large state-owned utilities (Engelken et al., 2016). In its turn, the transition of energy generation and consumption from fossil fuel to renewable energy technologies has affected the market structure of the electric power industry and has also transformed the way in which electricity is transmitted and sold (Richter, 2013a).

The technological advances that changed the market structure have allowed the creation of new approaches. For instance, there is the case of Decentralized Energy Systems (DES), which introduced a paradigm shift in the way energy is produced, delivered and consumed (Adil & Ko, 2016), as they part from the basis of Renewable Energy Technologies (RET) to create small-scale energy generation units that that deliver energy to local customers (Adil & Ko, 2016; Vezzoli et al., 2018).

In addition to these new technologies, the business environment is also changing as new actors emerge in the energy industry (Kotilainen et al., 2016). The electricity consumers experienced the changes in basically two different ways. First, consumers became able to freely choose an electricity supplier and to choose from a more diverse offering of products and services such as the most cost-effective supplier or a 'green' supplier. Second, consumers gradually moved into the position of themselves becoming an electricity producer as well as a consumer (Bellekom, Arentsen, & van Gorkum, 2016).

This type of producer + consumer have been called *prosumers,* and have been particularly enabled by small generation units for energy production (Vezzoli et al., 2018), predominantly by installing solar panels (Bellekom et al., 2016). This figure can be "an individual person as household level customer, a larger building (e.g. apartment building or shopping center), a business entity like organization or a firm, or other kind of community" (Kotilainen et al., 2016). In this way, prosumers, by becoming an active participant in the energy industry (Kotilainen et al., 2016), have influenced the creation of new business models, including the establishment of new market segments as well necessary regulatory policies (Inderberg, Tews, & Turner, 2018).

Still, the generation of new Business Models is not as straightforward as it seems.

iv. Relevance of the Systematic Literature Review

Although Sustainability has been a key issue in the last years, scholars still consider “Sustainable Business Models” as an emerging topic in academia (N. Bocken & van Bogaert, 2016; Boons & Lüdeke-Freund, 2013; Comin et al., 2019; Lüdeke-Freund, 2018). The main topics addressed in papers that study SBM from a general perspective include analysis such as: i) definition of the concept (Boons & Lüdeke-Freund, 2013), ii) attempts to systematically categorize the emerging SBM (N. M. P. Bocken et al., 2014) and, iii) literature reviews (Comin et al., 2019; Geissdoerfer, Vladimirova, & Evans, 2018; Nosratabadi, Mosavi, & Shamshirband, 2019) ; still, only a small part of the business models analysed by researchers concern the energy sector (Leisen et al., 2019a).

As has already been stated, there is a consensus regarding the definition of a BM as a set of activities for creating, capturing and delivering value, which implies the existence of a value chain structure; this suggests that the received literature on business models supports an activity system perspective (Zott & Amit, 2009).

Some authors go beyond that and have explicitly pointed out that BM need to consider the activities performed by a focal firm but outside its boundaries, addressing partners, suppliers or customers (Zott & Amit, 2009). In this way, value-capture is managed at firm-level, but value creation comes from inter organizational relationships, since it is co-created (Hellström et al., 2015). It can, thus, be stated that a BM is an appropriate unit of analysis for understanding value creation from a network perspective (Zott & Amit, 2009).

However, most of the research on BM topics is carried out regarding performance implications for a single firm or dyadic links between supplier and its customer (Hellström et al., 2015). For that reason, a research gap remains on changes in BMs resulting from network participation for sustainability (Rossignoli & Lionzo, 2018). The fact that the energy sector is a highly networked business in itself, provides an additional point for the need of the study of SBM from a system perspective.

Under this statement, this work attempts to present an analysis of **value creation in interorganizational relationships as a result of the adoption of Sustainable Business Models by a focal firm in the Renewable Energy Sector.**

As can be seen from the previous sections, several authors refer the importance of studying BM from a system perspective; at the same time, there is a trend in the theory of value creation that states that it comes from collaboration among firms. However, there is no evidence of studies that examine what the mechanisms for value co-creation is, nor if the different levels of analysis have an impact on it.

For that reason, the main research question has been defined as:

What are the mechanisms that enable closer collaboration among actors in the renewable energy industry to create sustainable value?

Also, a secondary research question is proposed:

Does the level of analysis, from individual to system perspective, have an impact on the definition of such mechanisms?

The chosen methodology is *Systematic Literature Review (SLR)*, which is intended to categorize the state of the literature on a specific topic or research question (RQ) (Burgers, Brugman, & Boeynaems, 2019).

For the operationalization of this research, the SLR considers SBM as a unit of analysis; from it, the different levels of analysis proposed by researchers are broken down and a typology of mechanisms that enable collaboration are proposed.

II. Methodology

This section is divided in two parts. The first one presents the methodology followed for the obtention of the papers and integration of the database that represented the main input for the elaboration of the systematic literature review (SLR).

i. Research steps

The SLR was conducted through a mixed methodology and it comprises three main steps. First, the main systematic search was carried out in SCOPUS database; secondly, the research was extended through a snowballing methodology (i.e. by reviewing the references cited in papers and referring directly to the original source for its revision), and, finally, all relevant papers were integrated in a database. The details of these steps are further described in this section and summarized in fig. 2.

SCOPUS was selected as the main database for developing this work, for several reasons. First of all it is one of the largest abstracts and citations databases in the peer-reviewed literature and it offers a comprehensive overview of the world's research production in the areas of science, technology, social sciences, among others (Comin et al., 2019). Secondly, its search tools include the possibility to perform Boolean searches, which in the case of this research were particularly helpful for including several possible combinations of key words in one search. It automatically generates an overall analysis of the results of searches, which are useful for detecting tendencies or specific centres of research. Finally, it provides users with the possibility to export results in different formats, including .*cvs*, which is convenient for working with the information to create a database.

From the research question: ***What are the mechanisms that enable closer collaboration among actors in the renewable energy industry to create sustainable value?***

Three key concepts are obtained: *Business Model*, *Sustainability* and *Renewable Energy*. These concepts were grouped in related keywords with the objective of performing a more comprehensive search. Consequently, the search query introduced in SCOPUS was:

("business model" OR "sustainable business model*" OR "best practice*") AND ("sustainable development" OR "sustainab*") AND ("renewable energ*" OR "renewable*")*

Also, the search was limited to *Title, Abstract or Keywords*, in an attempt to avoid false positives due to the relevant nature of the key concepts.

A total of 439 papers was obtained. The search was further limited by *Document type,* and *Subject Area,* selecting only papers related to engineering, energy, environment, business and economics, leaving 192 results. At this point, it was decided to apply another limitation by *Year*, since, from the analysis tools embedded in SCOPUS, it was very noticeable that the topic started emerging as a trend specifically in 2008.

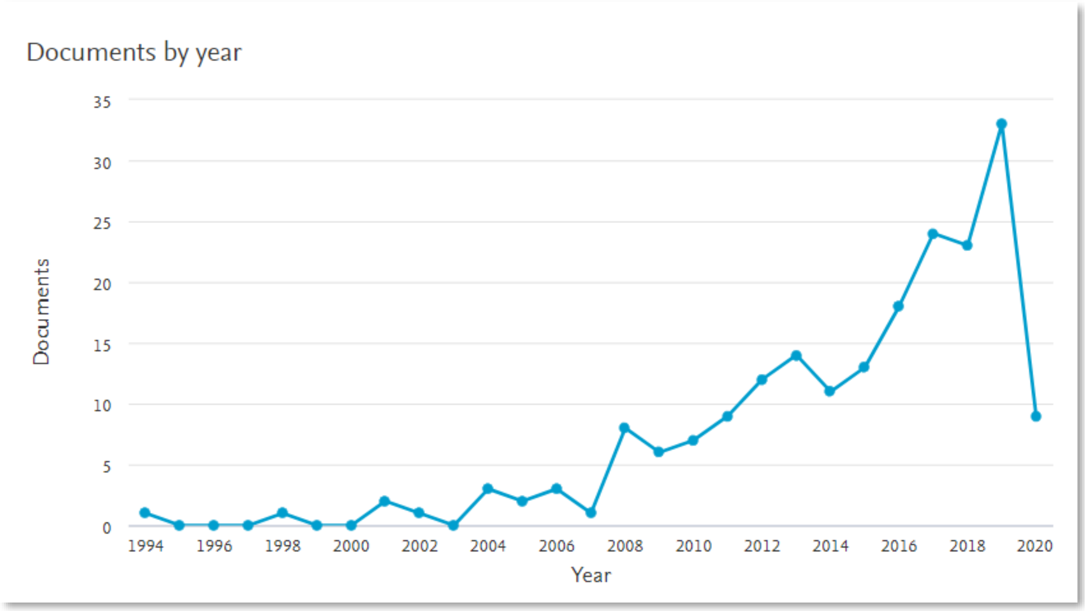

Figure 1. Trend of documents published yearly using the described query and including the proposed limitations.

After this last filter, a total of 187 papers was left. This first sample was the starting point for discriminating papers from its content.

A first scanning was made considering three variables: The title of the paper, its abstract and the keywords selected by the author. The papers that seemed to be useful to answer the research question were selected and exported in .cvs format to form a database in Microsoft Excel. The criteria for selecting an article was that the title, abstract or the keywords, included an analysis or a proposition of a BM or a series of best practices (BP) that helped an actor of the RE industry create sustainable value. It was important that the paper was developed in the context of RES whether it was a specific source or renewable sources in general. This first sample consisted of 69 papers.

Afterwards, a more careful reading was made by accessing the full version of the papers; the aim of this activity was to select the papers that were useful for answering the RQ and be included as the basis of the research. At this point, it was discovered that 23 papers could not be accessed with the credentials provided by PoliMi.

The rest of the papers was analysed for deciding whether they should be included in the final database or not. The criteria for a second discrimination was very similar to the first one, only, this time the screening was made on the entire body of each paper. After this process a number of 26 papers was left.

The second step for the selection of papers followed a *Snowballing* approach, which consisted on selecting papers from the citations of the first sample of papers. This activity was carried out by scanning the publications' title in the reference section and the context they were cited in the text. The abstracts of the papers identified as possibly relevant were then scanned and it was decided whether to add them to the final database. The newly added publications' references were scanned as well for relevant references. This process was repeated until a final number of 50 papers was reached; this, with the objective to have a manageable sample but containing enough papers to perform the analysis.

The following figure describes the flows of papers added in each step and sub step of the systematic literature review.

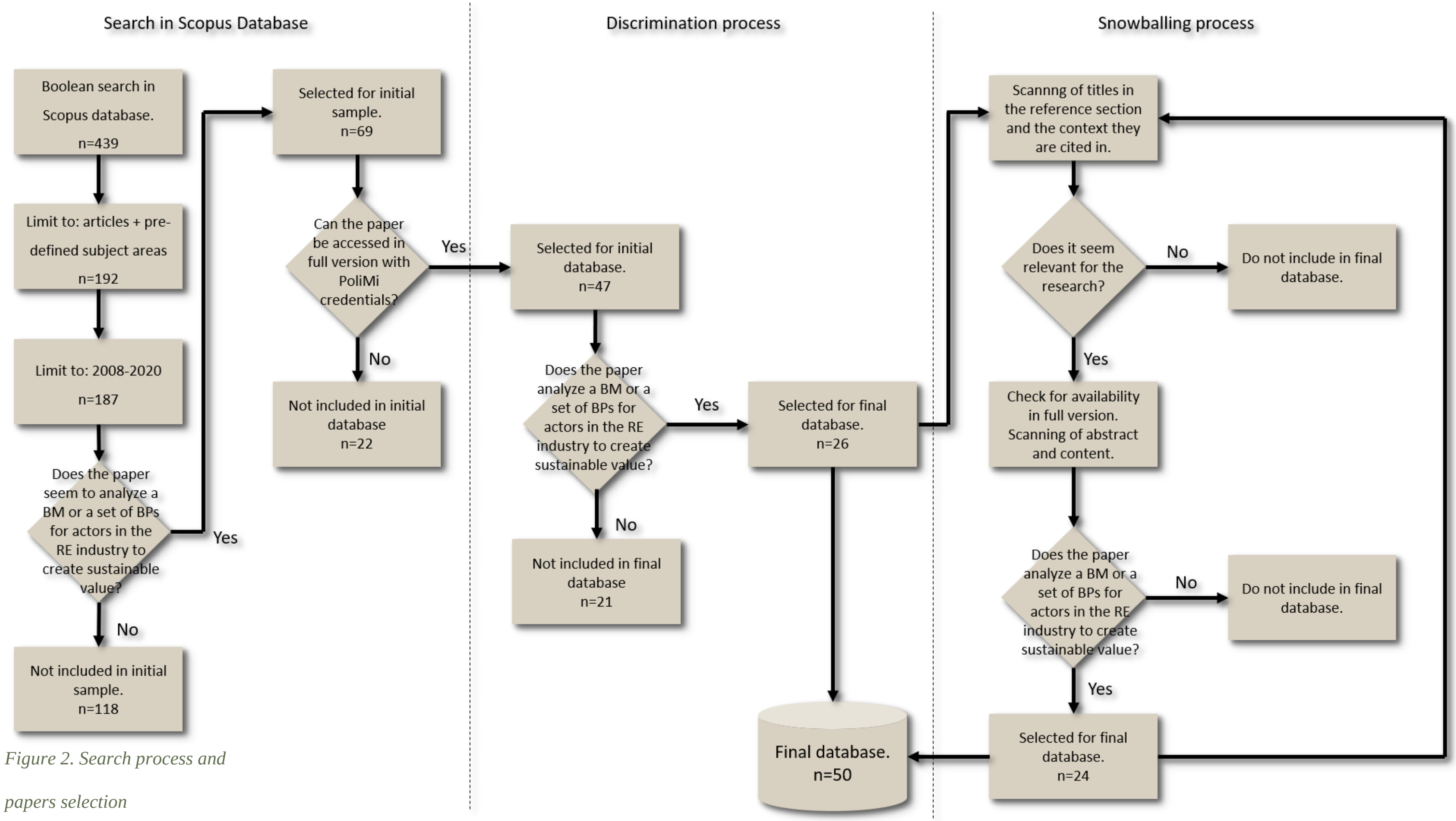

Figure 2. Search process and papers selection

The database was integrated by three sections. First, the general data from each paper was extracted, i.e. authors, title, year, abstract and author's keywords. Secondly, some cells were dedicated to obtaining further context from each paper: summary of the BM or set of BPs, methodology, and framework or theory, which were added only if the authors specifically mentioned them as part of their methodology. Finally, the energy-related information was extracted, including the RES that was indicated for the operationalization of the BM, and an additional paradigm that was necessary for the implementation, in case there was one. If there was no information about a specific renewable source, the word "general" was indicated. The following figure illustrates the data base resulting from the extraction of data.

Authors	Title	Ye	Abstract	Summary of the article: BM or BP	Methogology	Framework	RES paradigm	Additional paradigm	Author Keywords
Chen S., Chen H.H., Shen T.	**Suitable business models for innovation in different levels of the smart grid energy industry**	2020	An intelligent grid system makes the combination of various renewable energy technologies and changes in power supply and demand become more possible. Technology and innovation are considered the primary drivers of the next stage of economic growth in China, and smart grid (SG) energy management has developed as an emerging industry with the goal of lowering greenhouse gas emissions and increasing energy efficiency to attain sustainability. In this study, high-level, middle-level, and low-level managers from 102 successful grid companies in China completed questionnaires. The particular characteristics of four business models for innovation (novelty, lock-in, complementarities, and efficiency) are discussed, three distinct levels of SG (power supply side, grid side, and customer demand side) are considered (addressing process and elements), and effects of each business model for innovation are identified. Our findings yield important considerations for companies in the SG energy industry on how to successfully adapt their	Is it possible for companies to improve innovation performance by implementing a business model for innovation with Smart G rids technology? Our theory suggests a strong link between each business model for innovation and each level of SG energy industry	Clustering analysis from questionnaires.	none	General	Smart grid	business model for in customer demand sid side; power supply sid grid
Specht J.M., Madlener R.	**Energy Supplier 2.0: A conceptual business model for energy suppliers aggregating flexible distributed assets and policy issues raised**	2019	The ongoing digitalization of the energy sector opens up opportunities for novel business models which can help to overcome some of the challenges accompanying the sustainable energy transition. One necessity in a more decentralized energy system with high shares of intermittent renewables is the provision of flexibility. This paper empirically applies the business model generation approach of Osterwalder and Pigneur (2010) in order to enhance our understanding of these transition challenges. The insights gained indicate that the focus of business models in the electricity supply market has to switch to a customer-driven perspective. To this end, the conceptual business model of an "Energy Supplier 2.0" as a dedicated	Aim: Providing a Business model for utilities that benefits all actors involved and that could be realized without requiring extensive changes to either the regulatory framework within the EU or to the behavioral patterns of the private energy customers. Use of BM canvas applied to electric utilities. *Point out that their old business model does not suit a future electricity system. *Business environment analysis: problems of German electricity utilities and other stakeholders *Development of one exemplary BM	Esctructured empirical investigation.	BM Canvas	Small scale decentralized energy generation. (Rooftop PV, CHP and batteries are condsidered).	BM design through business model generation (BMG)..	Business model gene Distributed energy; En supplier 2.0; Energy su contracting; Flexibility; the future; Virtual pow

Figure 3. Extract from the final database

The next step was to extract relevant information from each paper that was useful for developing a longitudinal analysis and answering the RQs. The information extracted for the longitudinal analysis consisted of: i) Type of research, ii) Methodology followed, and, iii) Framework of reference, in case there was one.

The information regarding the RQs started with RES included in the proposition of the BM and any energy-related paradigm involved. Additionally, the papers were separated according to the level of analysis used by the researchers, since the second RQ required to specify the perspective of the paper. From this division, the first variable of the framework, which will be further explained, was developed as a theoretical proposition.

ii. Longitudinal analysis

This section presents some statistical data from the papers included in the final database.

The first analysis is related to the papers' publication years.

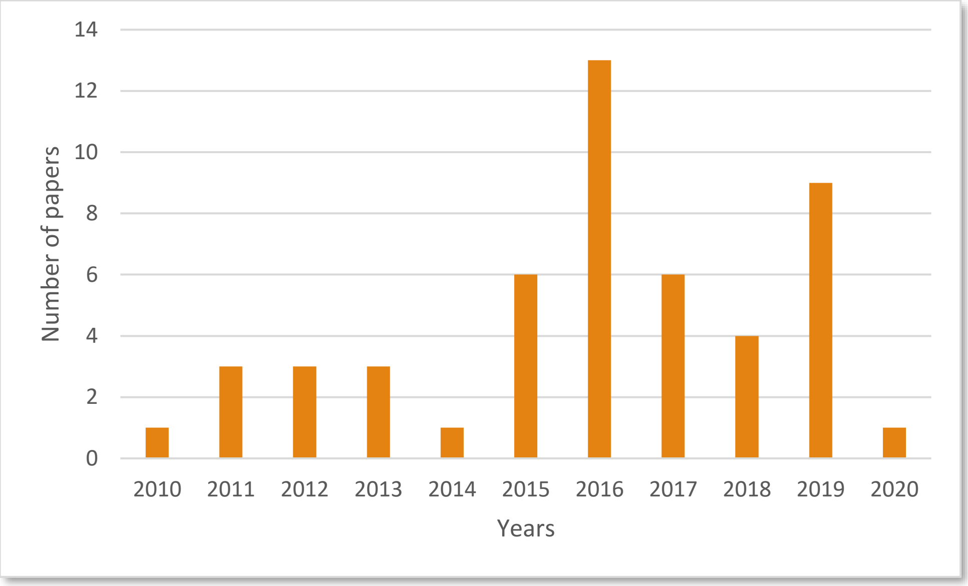

Figure 4. Number of papers reviewed from each publication year

It is noticeable from the graph that most of the publications belong in the second half of the time lapse predefined for the analysis, being the years with the highest number of papers 2016 and 2019. This situation is not unexpected, since the tendency obtained in the first sample of papers, clearly indicated an upward direction (see fig. 1).

It is important to state that, due to the moment this work is being developed and presented, year 2020 is included but its results are not definitive.

The second analysis of data concerns the methodologies followed by the authors for the development of their papers. The first observation was that, due to the nature of the subject areas selected in the search process, the great majority of the publications followed a qualitative methodology; in fact, only 4 publications contained a pure quantitative methodology.

The following table summarises the type of research and methodology followed by each of the papers included in the final database.

Table 1. Type and methodology of the papers

Type of research	Methodology	
Qualitative	Action research method	(Karlsson, 2019)
	Case study	(Ahlgren Ode & Lagerstedt Wadin, 2019; Budde Christensen, Wells, & Cipcigan, 2012; Dehdashti, 2019; Dilger, Jovanović, & Voigt, 2017; Emili, Ceschin, & Harrison, 2016; González, Gonçalves, & Vasconcelos, 2017; Hamelink & Opdenakker, 2019; Hellström et al., 2015; Huijben, Verbong, & Podoynitsyna, 2016; Khripko, Morioka, Evans, Hesselbach, & de Carvalho, 2017b; Nair & Paulose, 2014; Okkonen & Suhonen, 2010; Pereira, Specht, Silva, & Madlener, 2018b; Surie, 2017; Vanadzina, Pinomaa, Honkapuro, & Mendes, 2019; Wainstein & Bumpus, 2016)
	Comparative analysis	(Palit & Chaurey, 2011)
	Content analysis method	(Bryant, Straker, & Wrigley, 2018a; Lehr, 2013a; Mir Mohammadi Kooshknow & Davis, 2018a)
	Delphi method	(Nichifor, 2020a)

	Empirical study	(Bolton & Hannon, 2016; Specht & Madlener, 2019)
	Exporative research	(Buitenhuis & Pearce, 2012; Gsodam et al., 2015; Heaslip, Costello, & Lohan, 2016; Richter, 2013a, 2013b; Svanberg, Finnsgård, Flodén, & Lundgren, 2018)
	Inductive research	(Helms, 2016)
	Literature review	(Behrangrad, 2015; Jolly, Raven, & Romijn, 2012; Koirala, Koliou, Friege, Hakvoort, & Herder, 2016a; Medved, Lakic, Zupancic, & Gubina, 2017; Shomali & Pinkse, 2016)
	Semi-structured interview	(Bauwens, Gotchev, & Holstenkamp, 2016; Mirzania, Ford, Andrews, Ofori, & Maidment, 2019; Tayal & Rauland, 2017)
Qualitative + Quantitative	Multi method	(Akinyele & Rayudu, 2016; Hall & Roelich, 2016)
Quantitative	Agent-based modelling	(Bellekom et al., 2016; Boait, Snape, Morris, Hamilton, & Darby, 2019)
	Cluster analysis	(Chen et al., 2020)
	Case study	(He et al., 2011a)

The following figure presents a cummulative description of the number of papers per methodology.

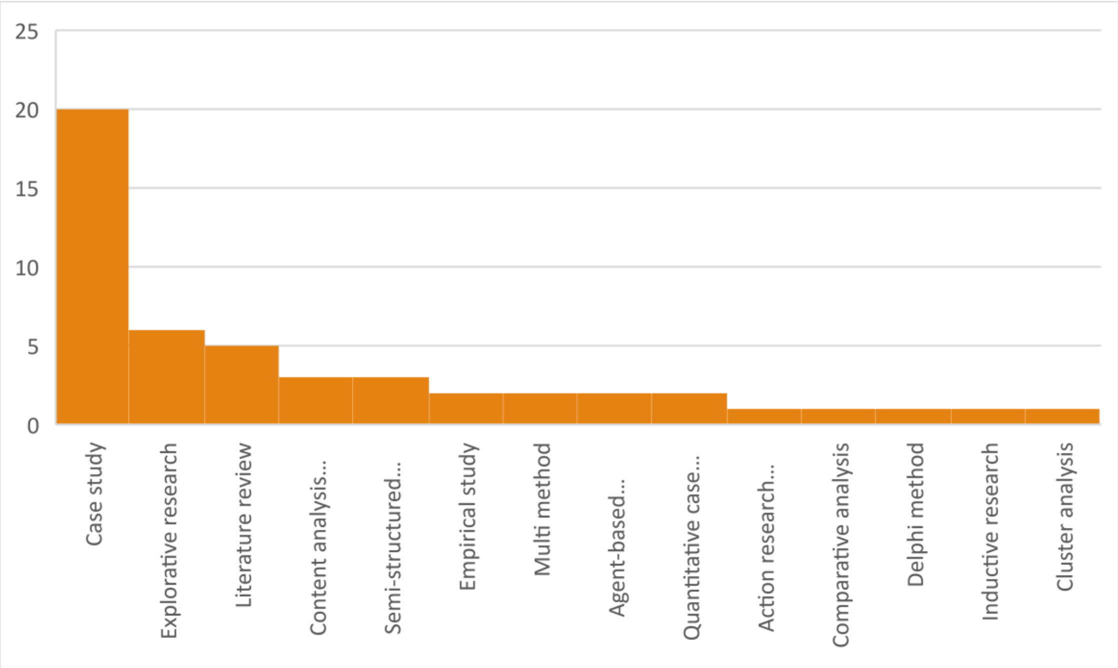

Figure 5. Number of papers per methodology

The graph shows that *Case study* was the most used methodology among the papers reviewed with 18 appearances, it was followed by *Explorative research* (6) and *Literature review (4).* These three methodologies cover 62% of the publications in the final database.

According to Ahlgren Ode & Lagerstedt Wadin, (2019), a case study research is appropriate when "a contemporary and complex phenomenon is explored, and the authors want to gain a holistic view and search for patterns in their observations". This definition fits the context of the phenomenon described in this research, since renewable energies are undergoing an unprecedented evolution, as stated in the first section of this work.

Richter, (2013a, 2013b) and Svanberg et al., (2018), agree that an explorative research strategy is suitable when a phenomenon is emerging or at an early stage, which, according to many authors, is the case of the study of Business Models.

The third part of this longitudinal analysis concerns the frameworks from which authors studied and described their findings. It is important to state that this piece of information was only added when it was openly declared in the paper; for that reason, not all the publications are included in this analysis.

The following table lists the frameworks mentioned and the papers they were used in.

Table 2. Frameworks used in the papers

Framework	
Activity system BM	(Bolton & Hannon, 2016)
BM innovation	(Dilger et al., 2017; Hamelink & Opdenakker, 2019; Hellström et al., 2015)
BoP	(Surie, 2017)
Bottom-up approach	(Mirzania et al., 2019)
Cascade framework	(Boait et al., 2019)
CSV	(González et al., 2017)
Flourishing BM canvas	(Karlsson et al., 2019)
Green BM	(Nair & Paulose, 2014)
Multi-level approach	(Svanberg et al., 2018)
Open innovation	(Buitenhuis & Pearce, 2012)
Osterwalder &Pigneur's BM conceptualization	(Bryant, Straker, & Wrigley, 2018b; Gsodam et al., 2015; Helms, 2016; Koirala, Koliou, Friege, Hakvoort, & Herder, 2016b; Mir Mohammadi Kooshknow & Davis, 2018; Nichifor, 2020; Richter, 2013b, 2013a; Specht & Madlener, 2019; Wainstein & Bumpus, 2016)
Social-ecological system	(Bauwens et al., 2016)

TBL	(Akinyele & Rayudu, 2016)
Teece's BM conceptualization	(Shomali & Pinkse, 2016)
Value mapping	(Khripko et al., 2017a)

The following figure shows the proportions of the most frequently used frameworks in the analysed papers. In this figure, *Osterwalder & Pigneur's BM conceptualization* is divided into two categories: *Four pillars* and *BM canvas*. This differentiation was made due to the fact that the researchers selected two different perspectives from the authors' theory. This is further explained below the chart.

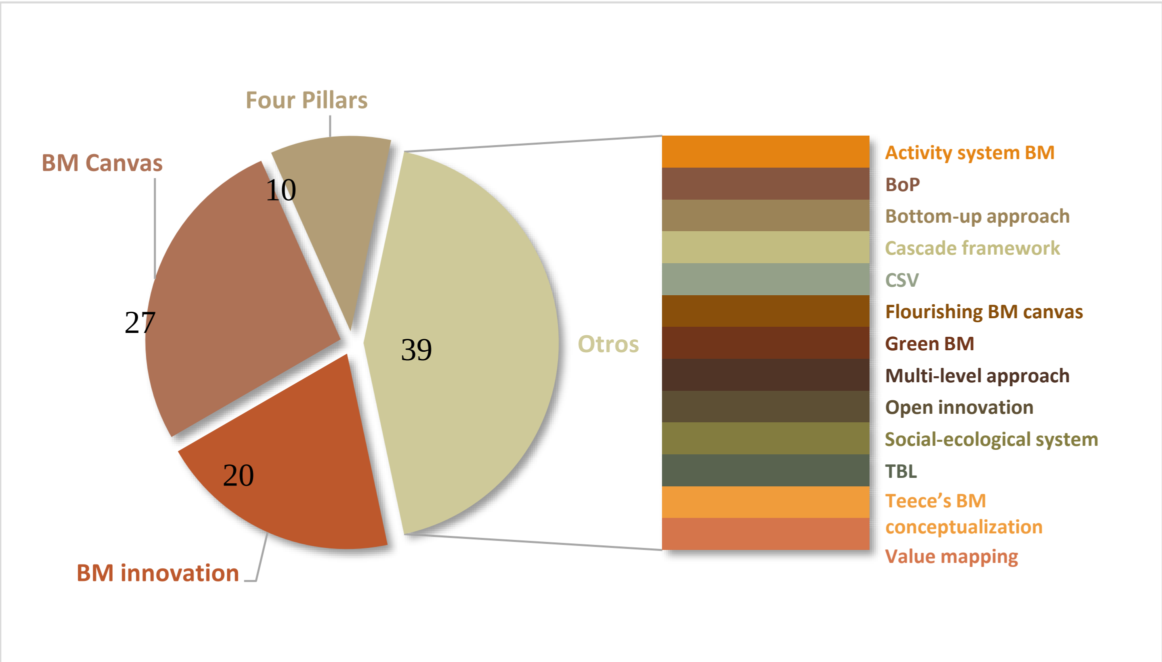

Figure 6. Frameworks used in papers

It is evident from the graph that Osterwalder & Pigneur's BM concept is the preferred framework among the authors under study. However, two different approaches of their theory were found in the papers.

About one third of the papers (Bryant, Straker, & Wrigley, 2018b; Gsodam et al., 2015; Koirala, Koliou, Friege, Hakvoort, & Herder, 2016b; Mir Mohammadi Kooshknow & Davis, 2018; Nichifor, 2020; Specht & Madlener, 2019; Wainstein & Bumpus, 2016) used the nine building blocks from the *Business Model Canvas (BMC)*; they are:

1. **Customer segments**: Groups of customers with distinct characteristics.
2. **Value proposition**: The bundles of products and services that satisfy the customer segments' needs.
3. **Distribution channels**: The channels through which the firm communicates with their customers and through which they offer value propositions.
4. **Customer relationships**: The types of relationships the firm entertains with each customer segment.
5. **Revenue streams**: The streams through which the firm earns revenues from customers for value creating and customer facing activities.
6. **Key resources**: The key resources on which the business model is built.
7. **Key activities**: The most important activities performed to implement the business model.
8. **Partner network**: The partners and suppliers the firm works with.
9. **Cost structure**: The costs the firm incurs to run the business model

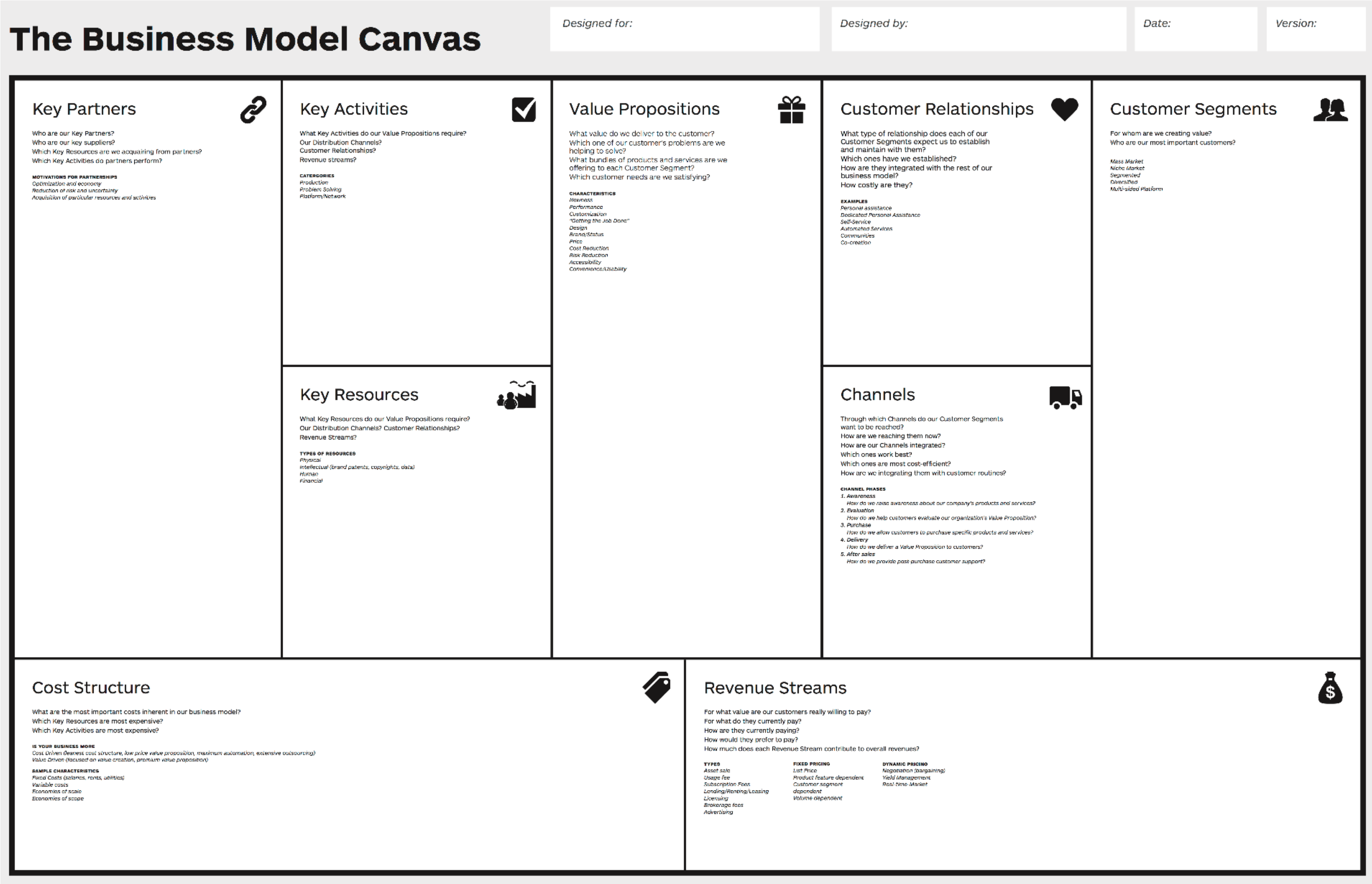

Figure 7. The Business Model Canvas

The second approach for Osterwalder & Pigneur's theory accounted for 10% of the publications; this conceptualization presents BM as a set of four pillars[1]. These four pillars are:

- Value proposition: Bundle of products and services that creates value for the customer and allows the company to earn create revenues.
- Customer interface: Comprises the overall interaction with the customer. It consists of customer relationship, customer segments and the distribution channels.
- Infrastructure: Describes the architecture of the company's value creation. It includes assets, know how, and partnerships.
- Revenue model: Represents the relationship between costs to produce the value proposition and the revenie that are generated by toffering the value proposition to the customers.

This conceptualization was used by Richter in two different publications (2013a, 2013b) and by Helms (2016), who directly referenced Richter in his analysis.

The third distictive segment is represented by the *Business Model Innovation (BMI)* concept, which concentrates 20% of the papers. Hamelink & Opdenakker, (2019) define BMI it as "The implementation of different modes of value proposition, value capture and/or creation". This concept was also studied from different approaches.

Hellström et al., (2015) developed a new framework for analysing BM innovation which attempts to demonstrate that the business model of a firm can be shaped through collaboration mechanisms in the context of an ecosystem in transition.

The following figure describes the framework.

[1] Since the cited paper could not be accessed, the definitions were taken from Richter, (2013a).

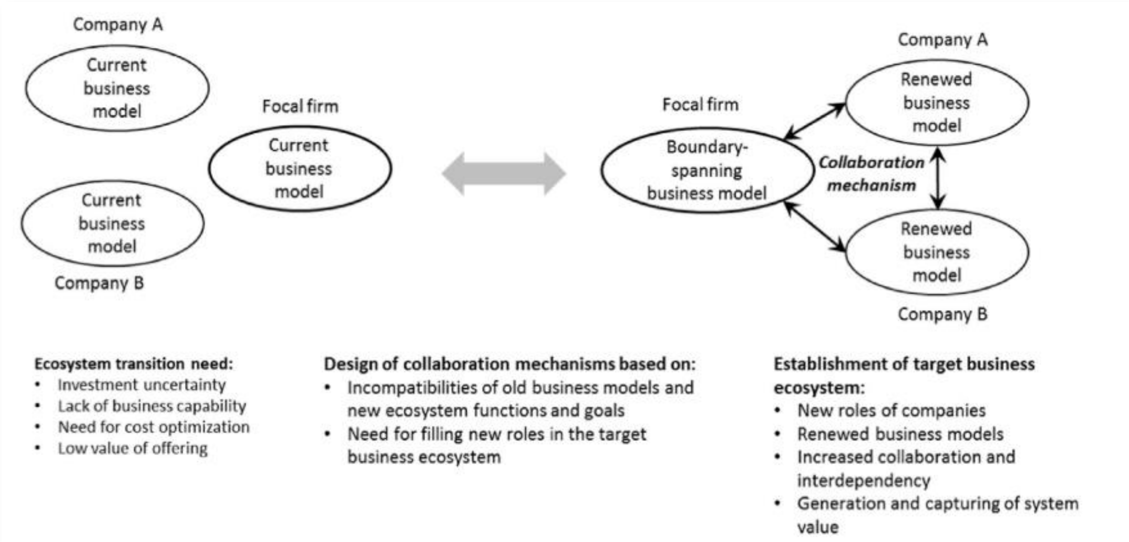

Figure 8. Framework for business model innovation in ecosystem transition context

Adapted from Hellström et al., (2015).

Hamelink & Opdenakker, (2019) made an adaptation from Clauss (2016)[2], for measuring business model innovation, based on three dimensions with several indicators each. These dimensions and their indicators are: i) Value creation innovation: New capabilities, New technology/equipment, New partnerships, New processes; ii)New proposition innovation: New offerings, New customers and markets, New channels, New customer relationships; iii)Value capture innovation: New revenue models, Value cost structures.

Finally, Dilger et al., (2017) use the 4I-framework by Frankenberger et al. (2013)[3],which highlights the specific challenges which managers face during the initiation, ideation, integration and implementation of new business models and allows a systematic BMI, by dealing with the barriers within the transformation process.

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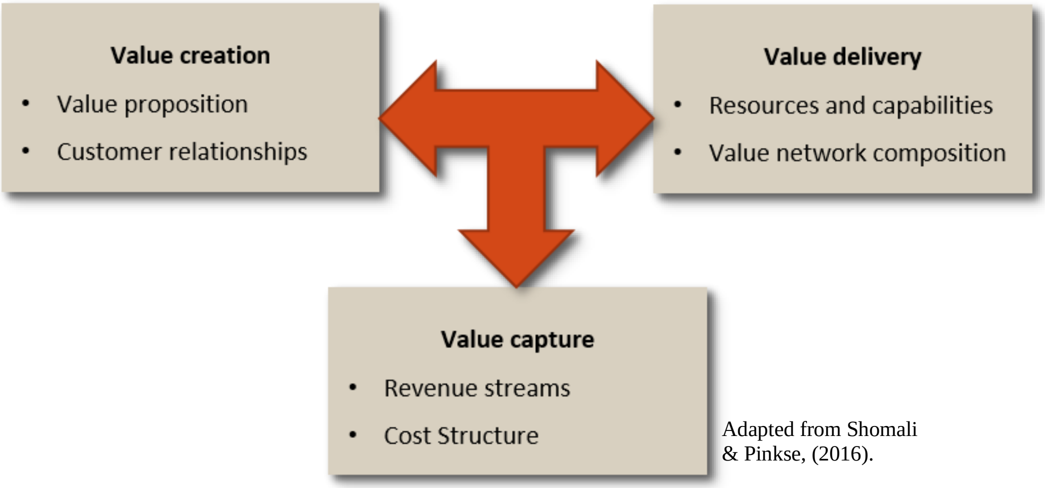
[2] The full version of the document could not be accessed. The reference is: T. Clauss, Measuring business model innovation: conceptualization, scale development, and proof of performance, R D Manag. 1 (2016) n/a-n/a, http://doi.org/10.1111/radm.12186.

[3] The full version of the document could not be accessed. The reference is: Frankenberger, K., Weiblen, T., Csik, M., Gassmann, O., 2013. The 4I-framework of business model innovation: a structured view on process phases and challenges. Int. J. Prod. Dev. 18 (3/4), 249e273.

The remaining 39% is composed by 13 different frameworks; each of them was used once in a paper. Still, three of them are related to BM conceptualization. The first one is another BM theory proposed by Teece, (2010), which differentiates three components in a BM: Value creation, value delivery and value capture.



Adapted from Shomali & Pinkse, (2016).

Figure 9. Teece's BM theory

The second BM theory is the *Activity Business Model* by Zott & Amit, (2010). Their theory describes a BM as “a system of interdependent activities that transcends the focal firm and spans its boundaries”, in other words an “activity system”. According to Bolton & Hannon, (2016) their approach stands out from others because instead of being firm-centric, the concept is directed towards a set of “ interdependencies and transactions between a focal firm and “its multiple networks of suppliers, partners and customers*”*.

The last BM-related framework is an adaptation of the BMC called *Flourishing Business Model Canvas*, which contextualizes the fundamental characteristics of a BM in three systems: environment, society and economy. The four perspectives for this contextualization are process, people, value, and outcomes (Karlsson et al., 2019).

The following figure illustrates the practical representation of the framework.

The flourishing business Canvas v2 (© Antony Upward/Edward James Consulting Ltd). All rights reserved. http://www.FlourishingBusiness.org. Used with permission

Figure 10. The Flourishing business Canvas Source: Karlsson et al., (2019)

III. Results

This section is divided in two parts. The first one shows the results regarding the RES found in papers, as well as some additional energy-related paradigms that form part of the BM analysed. The second one presents a framework that is proposed for answering the research question.

i. RES and Energy-related Paradigms

As stated before, during the discrimination process, one of the criteria to add a paper to the database was the presence of a RES generation technology. Having said that, nine different categories for RES were found in the selected publications. The following figure represents the percentages for each of them.

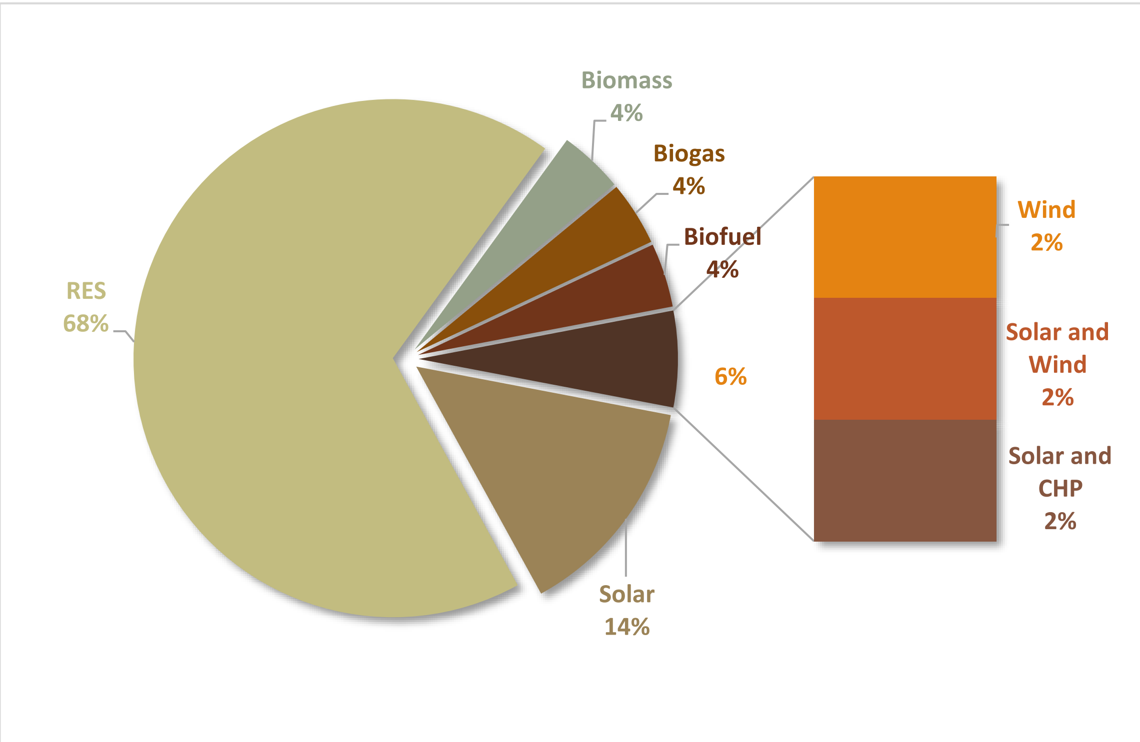


Figure 11. RES in the papers.

It is clear from the table that the majority of the papers include a generalized application of RES; i.e., the authors include renewables in their BM or set of BPs but do not specify a particular type. This category contains 68% of the papers.

There were five specific types of RES that were considered in BM in at least one paper: Solar (14%), Wind (2%), Biomass (4%), Biogas (4%) and Biofuel (4%). From the solar category, five papers considered Solar PV technologies (Ahlgren Ode & Lagerstedt Wadin, 2019; Bolton & Hannon, 2016; Buitenhuis & Pearce, 2012; Jolly et al., 2012; Medved et al., 2017), while two more papers did not specify their solar technology (Huijben et al., 2016a; Richter, 2013b).

Finally, two categories that contained a combination of two different RES were found: Solar & Wind, and Solar & CHP. This means that, when looking at RES individually, Solar is the most analysed by researchers.

As a second finding in this research, there is the fact that many of the RES found in the papers, needed another energy-related paradigm for its operationalization. This was the case for 66% of the papers.

The following table summarizes the paradigms and the publications in which they were found.

Table 3. Energy-paradigms additional to the usage of RES

Paradigm	
Demand-side management	(Behrangrad, 2015; Khripko et al., 2017b)
Distributed renewable energy systems (DRE)	(Bellekom et al., 2016; Bolton & Hannon, 2016; Emili et al., 2016; Hellström et al., 2015; Richter, 2013b; Specht & Madlener, 2019; Wainstein & Bumpus, 2016)
Electric vehicles	(Christensen et al., 2012)
Energy community	(Akinyele & Rayudu, 2016; Bauwens et al., 2016; Boait et al., 2019; Dilger et al., 2017; Hall & Roelich, 2016; Heaslip et al., 2016; Koirala et al., 2016a;

	Mirzania et al., 2019; Palit & Chaurey, 2011; Vanadzina et al., 2019)
Energy storage	(Dehdashti, 2019; Hamelink & Opdenakker, 2019; He, Delarue, D'haeseleer, & Glachant, 2011b; Karlsson et al., 2019; Mir Mohammadi Kooshknow & Davis, 2018b)
Smart Grid	(Chen et al., 2020; Pereira et al., 2018a; Shomali & Pinkse, 2016)

The following figure illustrates the proportion of papers that referenced each of these paradigms, as well as the one that included only RES.

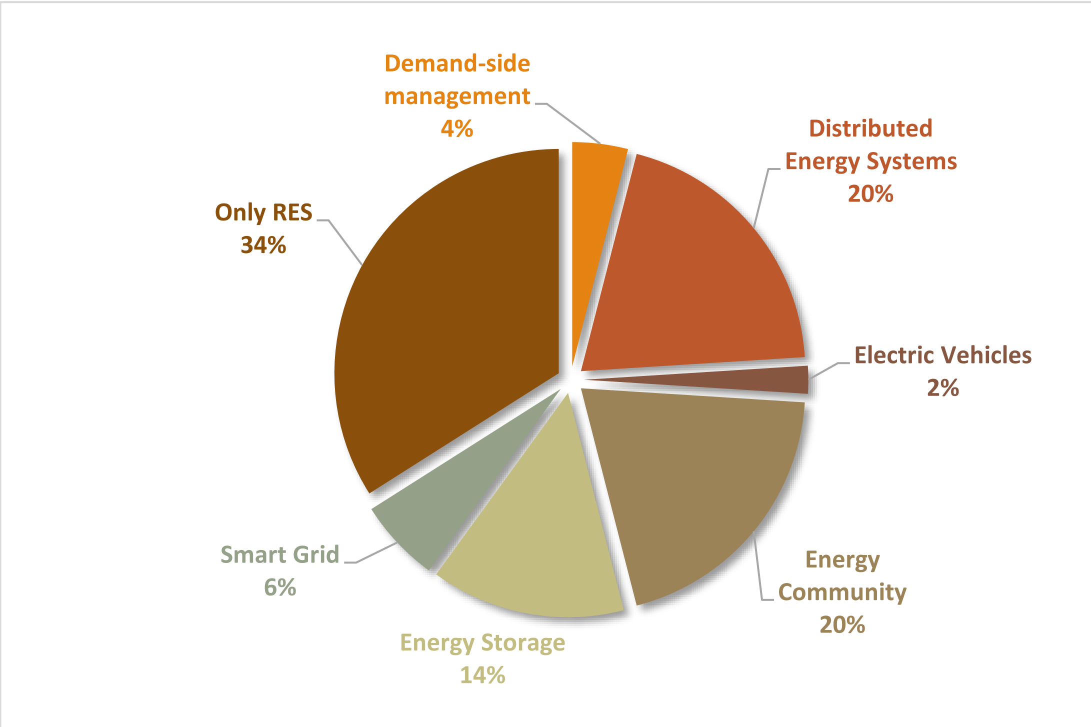


Figure 12. Additional energy-related paradigms

It is clear from the chart that the most frequently used paradigm for the operationalization BM in the context of RES is *Distributed renewable energy systems (DRE)*. This concept refers to an approach that employs small-scale technologies to produce electricity close to the end users of power. DRE technologies consist of modular generators, and they offer several potential benefits. In many cases, distributed generators can provide lower-cost electricity and higher power reliability and security with fewer environmental consequences than traditional power generators (Virginia Tech.). According to Vezzoli et al., (2018), it is the most promising paradigm for delivering sustainable energy to the masses.

This kind of energy generation represents a challenge in its operationalization since it involves a paradigm shift from the traditional way of generating and distributing energy.

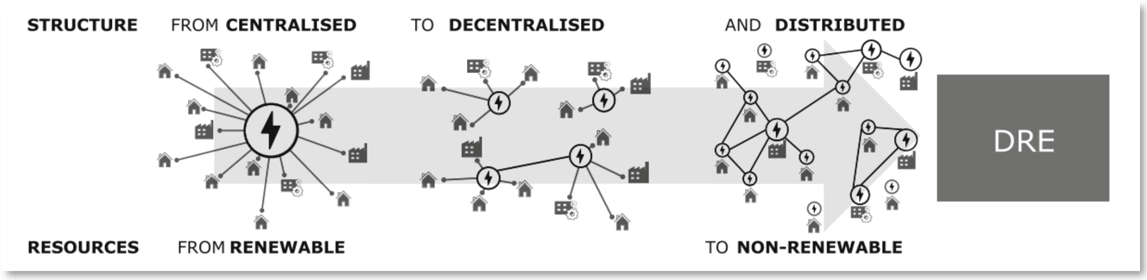


Figure 13. Paradigm shift from non-renewable/centralised energy generation systems to renewable/ distributed ones.
Source: Vezzoli et al., (2018)

The second most used paradigm was *Energy community*. An Energy Community is a legal entity where citizens, SMEs and local authorities come together, as final users of energy, to cooperate in the generation, consumption distribution, storage, supply, aggregation of energy from renewable sources, or offer energy efficiency/demand side management services (REScoop, 2020).

Energy storage also represents an important trend in renewable energy systems. These technologies provide multiple services in generation, transmission and distribution, as well as in end- user activities. Their function lies in a bi-directional transformation process: first, electricity is transformed into a storable form of energy at certain efficiency, and second, the stored energy is recovered rapidly into electric energy with certain losses in case of need. Therefore, the electricity storage technology is not an electricity generation means in strict sense, but a valuable flexibility resource adjunctive to all the resources in the power system, which can help achieving a higher asset utilization rate and contributing to the reliability of the power system, especially in the scenarios of massive intermittent renewable energy penetration (He et al., 2011a).

Smart grids are energy networks that can automatically monitor energy flows and adjust to changes in energy supply and demand accordingly (European Commission, 2020). They comprise a broad mix of technologies to modernise electricity networks, extending from the end user to distribution and transmission. The introduction of better technologies for monitoring, control and automation enable the development of new business models, and, at the same time, allow benefits at a system level including reduced outages, shorter response times, deferral of investments to the grids themselves and distributed energy resource integration (Munuera & Fukui, 2019).

Demand-side response (DSR) enables control of energy use during peak demand and high pricing periods, reducing peak demand (Martin et al., 2017). It helps integrate higher shares of variable renewables, including electricity storage, greater interconnection and more flexible power plants by shifting and shaping electricity demand to match the availability of renewables-based electricity generation (Bouckaert, Goodson, & Wanner, 2018). Traditionally DSR has been directed at large-scale industrial consumers manually shedding demand in times of system stress, yet over 75% of the global potential lies in residential buildings (Bouckaert et al., 2018).

A shift towards emerging business models that enable DSR has been happening slowly. They often have a strong digital component and activate flexibility from many distributed energy resources, and their numbers are on the rise (Munuera & Fukui, 2019).

ii. Proposed framework

This section presents the results of the research that aims at answering the RQs

- ***What are the mechanisms that enable closer collaboration among actors in the renewable energy industry to create sustainable value?;*** and
- ***Does the level of analysis, from individual to system perspective, have an impact on the definition of such mechanisms?***

Part of the development of the analysis was performed based on some other pre-existing frameworks and theories.

Different authors emphasize the need to be clear about value proposition and value capture when discussing BM (Hall & Roelich, 2016). This is particularly important in energy business models because they can deliver multiple benefits beyond the energy customer; to the energy system itself (e.g. energy efficiency measures), and to the wider economy (Hall & Roelich, 2016).

Being Osterwalder and Pigneur's conceptualization the most widespread among the studied authors, it was decided to focus on the part of their theory that best fit the concept of *value creation* (in order to better answer the research question). In the BMC this information is summarized in three building blocks Key resources, Key activities and Partner network. In the alternative approach, the value creation activities are contained in one of the pillars: Infrastructure.

Zott & Amit, (2010), conceptualize a firm's business model as a system of interdependent activities that transcends the focal firm and spans its boundaries. From them, the idea taken was that not only the activities performed by a firm have to be considered, but also those carried out by their partners.

From Huybrechts, (2014), the idea of three levels of analysis was taken; he states that when it comes to the pursuit of a more sustainable economic model the levels are: Systemic level, Individual level and an Intermediate level that forms a bridge to go from *individual* change to *systemic* change.

Hellström et al., (2015), were the main source for understanding the concepts of *collaboration mechanisms* and *value co-creation.*

These propositions were taken as basis for the understanding of BM and BP found in literature; consequently, the research derived in the proposition of a new framework for analysing the mechanisms that enable collaboration for value creation in the renewable energy sector, from the perspective of different levels of analysis.

Consequently, the first variable to look at, was the level of analysis proposed in each of the papers. As explained before, this variable was proposed ex-ante as an initial categorization of the selected papers. Thus, three different levels were pre-defined.

1. **Company level:** The analysis carried out by the researchers was focused on a single company or a group of comparable companies. In the end, the conclusions and suggestions that could be held as valid for other comparable companies.

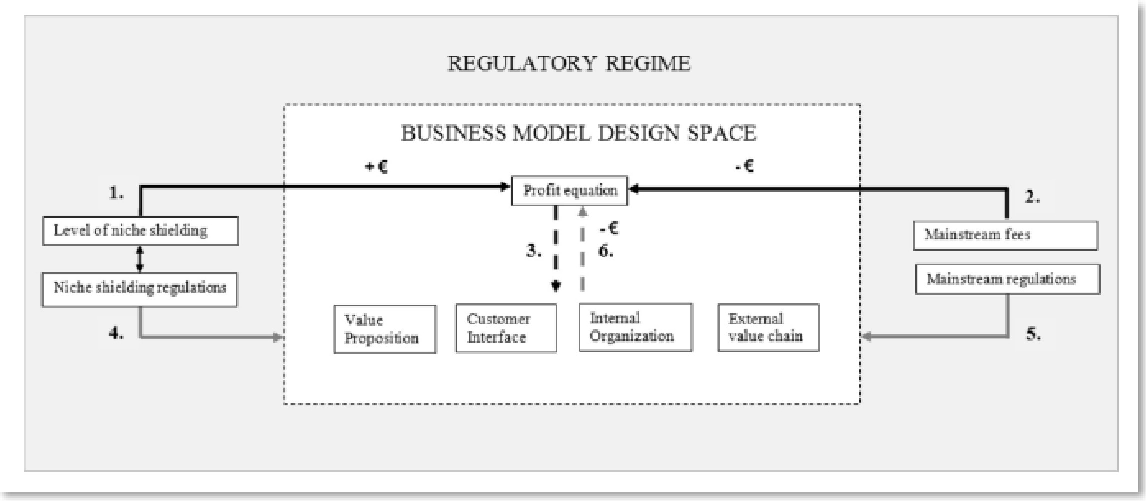
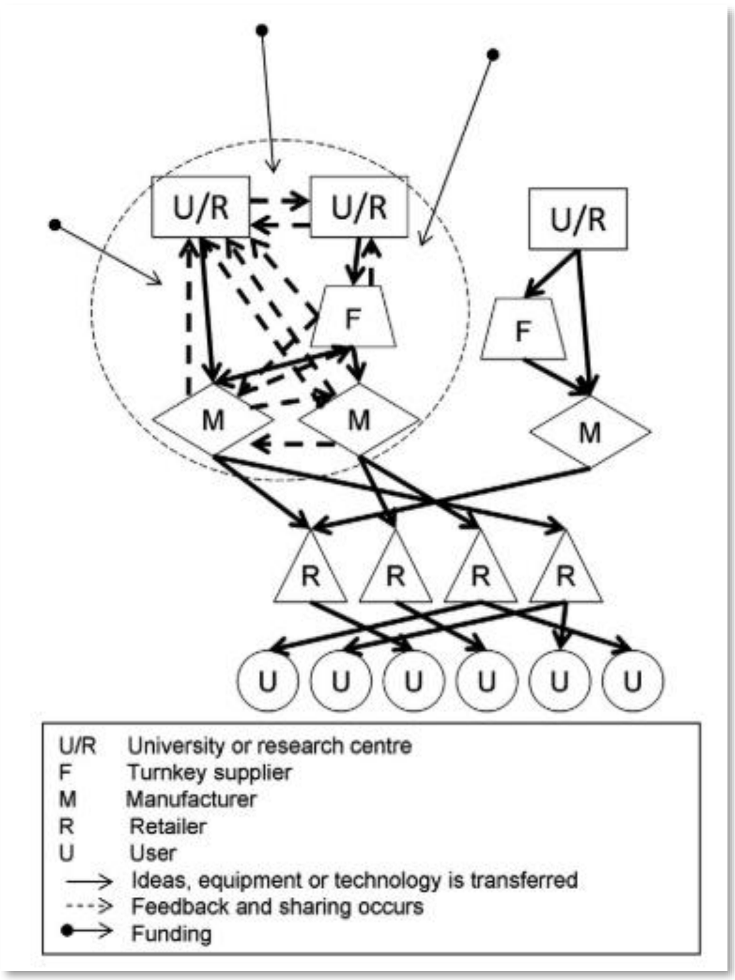


Figure 14. Example of an analysis from a company perspective. Source: Huijben et al., (2016a)

2. **Value chain level:** The study focuses on the analysis of the value chain or a part of a value chain of a company, particularly on the relations supplier-company or company-customer. The main difference between this level and the "System" level is that this aims at analysing the direct relationship between suppliers and customers. This level was easy identifiable in the papers as the renewable energy generation and consumption is known.

Figure 15. Example of the electric power value chain Adapted from Richter, (2013a)

3. **System level:** The paper analyses the interactions among most of the stakeholders of the BM, including suppliers, customers and policy makers.



Source: (Buitenhuis & Pearce, 2012)

Figure 16. Example of an analysis from a system level

Despite the level of analysis used by the researchers, the BM found in papers include a *focal firm*, i.e. the perspective from which activities and collaborations are referred.

The second variable for the development of the framework was the *Mechanisms that enable collaboration.* For its analysis and understanding it was necessary to define a focal firm for each case.

This variable focuses on the series of strategical activities a focal firm needs to perform to collaborate with other actors, being these actors all the ones considered by their BM. Basically, the proposed categorization depends on the level of change or adaptation needed; in other words, this variable establishes how much a focus company needs to adapt their current activities to establish a collaboration with other stakeholders.

The categories are:

1. **Basic synergies:** This level refers to BM that rely to some extent on the development of partnerships among actors, but that does not require any of them to develop new capabilities. For instance, stablishing a collaboration supplier-customer with a new supplier.
2. **New functions:** This level is appropriate when, in order to allow the collaboration with others, the focal firm needs to adapt their structure, organization or develop new capabilities.
3. **New actor:** The last level describes a situation in which, for the correct implementation of a BM, there is the need of the creation of a new actor. For that reason, the collaborations among participants adapt in a completely new way. This level considers the possibility that the focal firm is the new actor or participates in its creation.

The following figure describes the proposed framework.

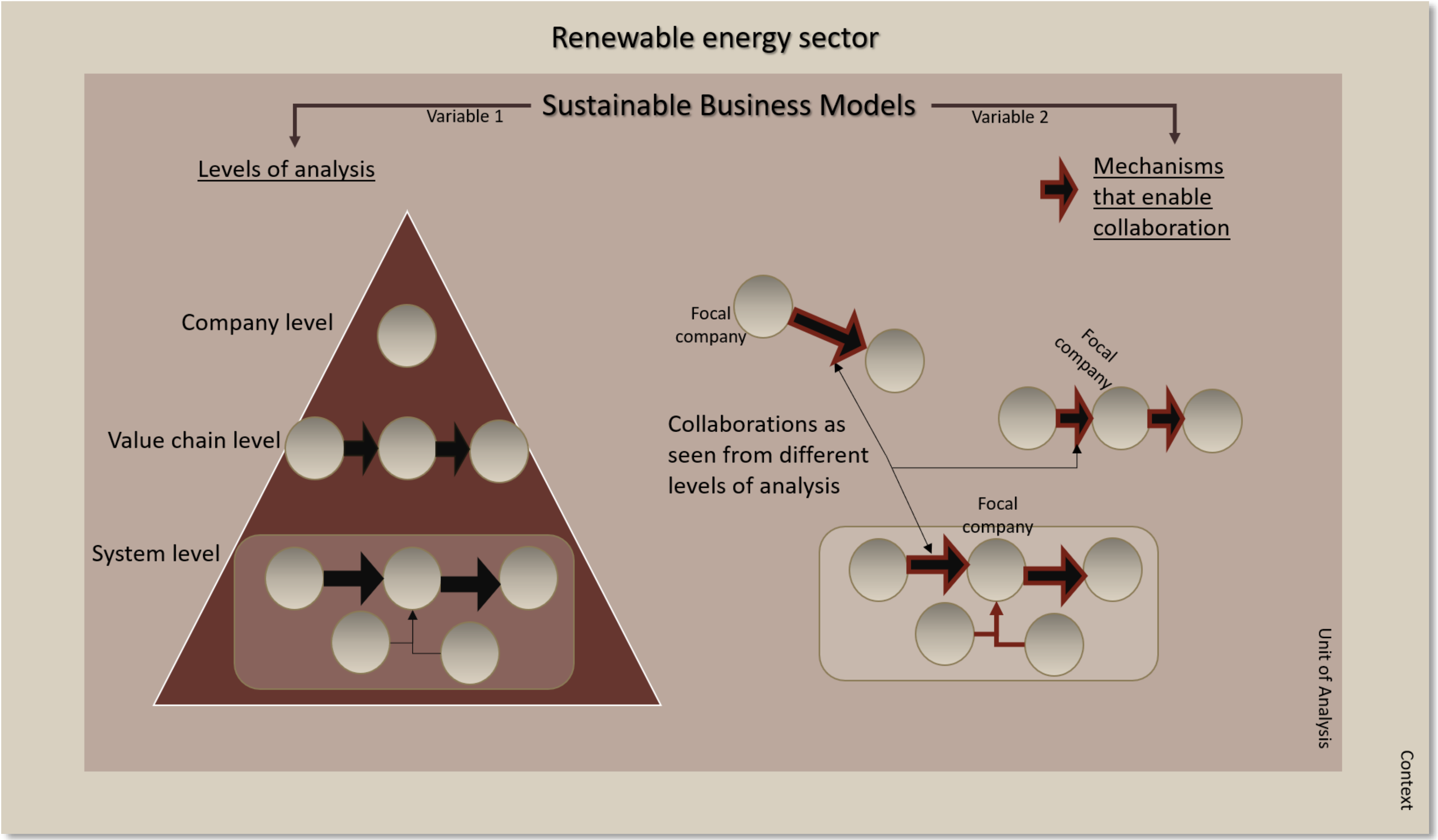


Figure 17. Proposed framework

The following table summarizes the results of both variables.

Table 4. Proposed framework

PERSPECTIVE	Source	MECHANISMS		
		Basic synergies	New functions	New actor
Company level	(Richter, 2013a)			✓
	(Ahlgren Ode & Lagerstedt Wadin, 2019)		✓	
	(Richter, 2013b)		✓	
	(Palit & Chaurey, 2011)		✓	
	(Nichifor, 2020a)	✓		
	(Gsodam et al., 2015)		✓	
	(Lehr, 2013a)		✓	
	(Hall & Roelich, 2016)		✓	
	(Wainstein & Bumpus, 2016)		✓	
	(Bolton & Hannon, 2016)		✓	
	(Huijben et al., 2016a)		✓	
	(Shomali & Pinkse, 2016)		✓	
	(Bryant et al., 2018a)		✓	
	(Medved et al., 2017)	✓		
	(Vanadzina et al., 2019)	✓		
Value Chain level	(Svanberg et al., 2018)	✓		

	(Christensen et al., 2012)			√
	(Hellström et al., 2015)			√
	(Hellström et al., 2015)		√	
	(Hellström et al., 2015)	√		
	(Nair & Paulose, 2014)		√	
	(Hamelink & Opdenakker, 2019)	√		
	(Hamelink & Opdenakker, 2019)		√	
	(Emili et al., 2016)	√		
	(Chen et al., 2020)		√	
	(He et al., 2011b)	√		
	(Behrangrad, 2015)	√		
	(Mir Mohammadi Kooshknow & Davis, 2018a)	√		
	(Khripko et al., 2017a)		√	
System level	(Heaslip et al., 2016)		√	
	(Specht & Madlener, 2019)		√	
	(Buitenhuis & Pearce, 2012)		√	
	(Bellekom et al., 2016)		√	
	(Akinyele & Rayudu, 2016)		√	
	(González et al., 2017)		√	
	(Pereira et al., 2018a)		√	
	(Dehdashti, 2019)			√

	(Mirzania et al., 2019)		✓	
	(Boait et al., 2019)		✓	
	(Helms, 2016)		✓	
	(Koirala et al., 2016a)			✓
	(Tayal & Rauland, 2017)		✓	
	(Bolton & Hannon, 2016)		✓	
	(Bauwens et al., 2016)		✓	
	(Surie, 2017)		✓	
	(Okkonen & Suhonen, 2010)		✓	

The first analysis of this framework is regarding the *Level perspective:* From the analysed BM, 15 were done at a company level, 14 at value chain level and 17 at system level. After comparing the results, it was clear that researchers have a preference for one level or another depending on the context of their study.

The *Company Level* perspective was preferred for analysing: i) National and/or regulatory contexts of the Renewable Energy Industry; particularly for stablishing a proven BM in a different geographical market (Ahlgren Ode & Lagerstedt Wadin, 2019), for studying opportunities and barriers given a regulatory framework (Bolton & Hannon, 2016; Richter, 2013b), for understanding a national context (Gsodam et al., 2015; Nichifor, 2020b; Richter, 2013a), or a particular local context (Palit & Chaurey, 2011); ii) a BM with a especial focus on the value proposition (Bryant et al., 2018a; Hall & Roelich, 2016; He et al., 2011a; Medved et al., 2017; Vanadzina et al., 2019; Wainstein & Bumpus, 2016); and, iii) The effect that energy-related trends have on incumbents BM (Huijben, Verbong, & Podoynitsyna, 2016b; Shomali & Pinkse, 2016).

The *Value Chain* perspective was used when the object of study was: i) The value chain of a local industry (Christensen et al., 2012; Hellström et al., 2015; Svanberg et al., 2018); ii) The value chain of an energy-related paradigm, such as energy storage (Hamelink & Opdenakker, 2019; He et al., 2011a) or smart grids (Chen et al., 2020); and, iii) The electric power value chain (Behrangrad, 2015; He et al., 2011a; Khripko et al., 2017a; Mir Mohammadi Kooshknow & Davis, 2018a).

Finally, a system perspective was taken when researchers included additional actors to the value chain, such as: i) Government or policy makers (Bauwens et al., 2016; Heaslip et al., 2016; Specht & Madlener, 2019; Wainstein & Bumpus, 2016); ii) Research centres or universities (Buitenhuis & Pearce, 2012; Pereira et al., 2018a); iii) A local community (Boait et al., 2019; González et al., 2017; Mirzania et al., 2019; Surie, 2017); iv) Service companies different from traditional suppliers (Bellekom et al., 2016; Dehdashti, 2019; Helms, 2016; Koirala et al., 2016a; Okkonen & Suhonen, 2010); and, v) financial institutions (Tayal & Rauland, 2017). This last perspective was the most dynamic, since several papers included more than one of the mentioned actors; for that reason, the citations included work only as examples.

The following table summarizes the level-perspective findings.

Table 5. Level perspective

Perspective		Dimensions
Company level	i.	National and/or regulatory contexts of the Renewable Energy Industry.
	ii.	BM with an especial focus on the value proposition
	iii.	The effect that energy-related trends have on incumbents BM.
Value chain level	i.	The value chain of a local industry .
	ii.	The value chain of an energy-related paradigm, such as energy.
	iii.	The electric power value chain.

System level	i. Government or policy makers. ii. Research centres or universities. iii. A local community. iv. Service companies different from traditional suppliers. v. Financial institutions.	

The second variable that composes the proposed framework are the *Mechanisms that enable collaboration.* As explained before, it consists of three different types, and the findings in the papers allowed to add several dimensions and, in the case of *New functional mechanisms* even some sub-dimensions in some of them.

The first relevant finding was that the dimensions for each type of collaboration mechanism were consistent regardless of the level perspective adopted in the study. For that reason, all the results presented include the three levels.

The dimensions for *Basic synergies* are summarized in the following table and further explained with the specific information found in the papers.

Table 6. Basic synergies

Collaborative mechanism	Dimensions	Definition
Basic synergies	1. Purchasing	The focal firm collaborates with another actor in the sense that one makes an acquisition from the other, reducing the collaboration to a purchasing action.

2.	Exploitation of a current asset or capability with a new purpose	In order to collaborate with other actors in the implementation of the BM, the focal firm makes use of a current asset or capability in a new way.
3.	Extension of current activities or services	The focal company modifies the reach of their activities or services in a way that does not imply developing new capabilities.
4.	Co-planning of activities	The focal firm collaborates directly with another actor for developing joint activities.

The *Purchasing* dimension was found in Hamelink & Opdenakker, (2019),.The operationalization of the BM implies the addition of a storage system to the offering of the focal firm; they create a new supplier relationship to manage it.

This dimension was also found in Nichifor, (2020a) whose results show that the main trend for wind and solar energy producers is to make partnerships and sell energy to trading companies, as they can benefit from the flexibility of negotiating the price and getting better contracts.

He et al., (2011a), propose a new business model that allows aggregating multiple revenue streams of electricity storage in a systematic way. The model consists in coordinating a series of auctions in which the right to utilize the storage unit is auctioned to different actors upon different time horizons, i.e. hours, days or weeks. The model proves that it is technically possible to coordinate the use of the storage unit by different actors. However, this solution is implemented through an algorithm and acquired as a technological purchase.

Medved et al., (2017) studied the mechanisms through which households can participate in the RE industry. By providing flexibility of their demand, investing in rooftop PV generation, electro mobility and local electricity storage, the household consumers can act as prosumers. These are achieved by making partnerships with providers or simply acquiring the product/service.

The second dimension, *exploitation of a current asset or capability with a new purpose,* was found in Vanadzina et al., (2019). Their *Fusion Grid* project intends to provide electricity and connectivity to the rural communities in emerging markets. It consists of solar PV and back-up battery energy storage system (BESS combined with 4G LTE Kuha† base station), which is a portable mobile network solution designed for rural areas without or limited network coverage. The core idea of this BM is to create a network, which would connect people within the community and establish a market; i.e. an extension of the electrification purpose.

The third dimension, which regards an *extension of the current activities or services,* was found in Svanberg et al., (2018) whose proposition for a municipal waste treatment company is to collaborate with local stables for the recollection of horse manure to feed their already existing biomass plant.

Emili et al., (2016) developed a framework for suggesting DER firms ways of expanding the impact of their BM. The mere purpose of the framework is to amplify an impact without consuming more resources. Two cases were analyzed: In the first case, the change was regarding the payment orientation that does not require the company to make any additional collaborations nor acquisition of capabilities; in the second case, the alternative BM provides the firm with the possibility to serve an additional type of customers with their current infrastructure.

Mir Mohammadi Kooshknow & Davis, (2018a) analyse and propose a series of alternatives for the focal firm to choose one customer or another (energy company, TSO, end customer) and to retain ownership of the system or leave it to the customer. However, no particular changes are needed for stablishing the different alternatives.

The last dimension for the basic synergies is c*o-planning of activities*; it was found in Hellström et al., (2015). They study the case of a biogas producer that depends on the supply of hay from a farmer; the problem they face is that the gas production is unstable because hay supply is unstable, causing lack of reliability from its customers. The solution is found when both companies collaborate for making a joint production planning. The biogas producer benefits from the stable hay supply to better serve their clients, while the farmer obtains fertilicer from the gas producer to increase value for their customers.

The second collaboration mechanism, *New functions,* was divided into three dimensions and ten sub-dimensions. As previously stated, this mechanism implied a relevant change in at least one functional aspect of the focal firm; the proposed dimensions aim, precisely, at describing the chatacteristic that best represents the change. The three dimensions are: i) New structure, which refers to the addition of an area or department, a strategic restructuration of divisions or assets, or even an addition to the firm in the form of M&A; ii) New capabilities, which refer to the need of incormporating knowledge or capacities to the current capacities of the firm; and iii) New organizational model, which refers to a change in the *business orientation* of the company, i.e. a modification that challenges their current business philosophy.

The following table describes the dimensions and sub-dimensions for *New functions.*

Table 7. New functions

Collaborative mechanism	Dimensions	Sub-dimension	Definition In order allow their collaboration with other actors, the focal firm needs to:
New Functions	1. New structure	i. External	Integrate vertically or realize M&A.
		ii. Internal	Perform strategical restructuring or relocation of assets.
	2. New capabilities	iii. Technical	
		iv. Managerial	Acquire new competences in a specific area.
		v. Financial/ trading	
	3. New organizational model	vi. Flexibility	Be able to adapt better and faster to external environment.
		vii. Servitization	Adapt to a service-oriented strategy

viii.	Customer-orientation	Follow a “user-centred approach”, individually or as a community.
ix.	Co-existence of BM	Adapt the organization to include additional BM.
x.	Joint-benefit	Collaborate directly with an actor to benefit from a single offering or asset.

In the case of *New functions,* three dimensions and ten sub-dimensions were found. An interesting finding of this type of mechanism was that the papers that fell in this category did not contain only one dimension; on the contrary, the actions needed for the implementation of a BM or set of BPs were composed by a mixture of several sub-dimensions . This means that, for instance, if a focal company decides to acquire another company for accomplishing their strategy, it is very likely that, in doing so, they will need to expand their managerial capacities. Only a few examples were found where the focal company required actions from only one dimension or sub-dimension.

Heaslip et al., (2016) studied three successful energy communities for understanding the reason of their success. They suggested a 5-step methodology for stablishing an energy community: commit, identify, plan, take action and review. The crucial point is to allow the participation of the whole community in the last two steps, for which a new more flexible organization (vi) is needed.

Ahlgren Ode & Lagerstedt Wadin, (2019), focused their research on the challenges that arose when trying to establish a proven BM in a different geographical market. Some of the barriers were a different regulation, different consumer behaviour and different building characteristics. Their solution was to adapt their tools (software) to the specific needs of the local customers (viii) and allow the co-existence of two different BM (ix).

Karlsson et al., (2019) analysed a farm-based biogas firm. The company had not been as successful as expected; for that reason, the research aimed at developing a new BM. They developed four distinctive pathways that can be summarized in: a) Increased cooperation and novel partnerships; b) Improved marketing/visibility, that involves the creation of a new division, marketing (ii); c) Sustainability brand creation (ii); and, d) Servitization: more distribution channels and complementary services (vii).

Hellström et al., (2015) studied the case of a biogas producer and a truck dealer, which sells gas trucks as a marginal business line. As they could have a common customer (Gas truck owner-gas consumer), they focused on finding an alternative for them to enable closer collaboration and value creation and capture. The solution was the design a new BM to promote a joint offer (x) for the same customer, offering transportation & fuel. Their internal functions had to adapt to the collaboration (ii).

Nair & Paulose, (2014) carried out a research to find a solution for reducing harmful emissions from the airline industry. They designed a business model for the development of a new energy source (biofuel), from the supply of raw material, to the delivery for the end-user (airlines). Authors suggest that some of the existing channels for fuel production and delivery can still be used; however, the sourcing of raw materials (farming and harvest) is an additional activity that has to be developed (i & iv).

Specht & Madlener, (2019) aimed at developing a BM for utilities for incorporating DER as part of their offering to customers, in the context of the existing regulatory framework. They propose a BM focused on a customer-driven approach (viii) and a shift in function of utilities from "generator" to "dedicated aggregator". The changes in the functions of actors are many: a) Utilities have to approach customers in a different way and with a different offer, providing a commodity, but also some related services in the form of an individually optimized bundle of DERs (vii); b) to provide the service, utilities have to arrange other collaborations such as exclusively branded products and reliable local installers (ii); c) they need a platform/algorithm to aggregate decentralized generation and match supply/demand (iii); and, d) their relationship with DSO has to become highly cooperative (vi).

Richter, (2013b), also explored the case of utilities to provide them with suggestions on how to overcome barriers for BM innovation. Having identified the barriers, the author proposed a series of recommendations following the building blocks of BM canvas: a) a new value proposition including new products and services (vii); b) a proactive approach to communicate added value to customers (viii);and, c) new capabilities in distributed generation (iii) and asset management (iv) need to be explored and developed.

Hamelink & Opdenakker's aim, (2019), was to study if energy storage could be a driver of BM innovation in the energy industry. They found that energy storage could enable BM innovation since it implies the elaboration of a new product for new customers using new channels (ii); the biggest value they provide their customers with is that of offering more flexibility (vi).

Palit & Chaurey, (2011), investigated BM adopted in South Asia for off-grid electrification. The different BM analysed in four countries (Sri Lanka, India, Bangladesh and Nepal) converge in providing their customers with more flexibility in their service (viii), particularly by introducing some payment options, which obliged them to acquire capabilities in financial schemes (v) such as fee-for-service, leasing and consumer financing, and micro financing.

Buitenhuis & Pearce, (2012), developed a research on how open-source design could be used to boost innovation in the PV industry. They found four different BM that allowed collaborations for a set of pre-stablished players. These different arrangements would require certain degree of adaptation in their functional structure (ii). The possibilities are: a) The partnership model (vi) ; b) the franchise model that would enable sharing of intellectual property and collaboration (x); and, c) the secondary industry model and the completely open-source design, both aim at shifting the PV industry into a more open environment (vi), being the latter completely open.

Bellekom et al., (2016), study how the presence and expansion of solar panels, residential storage and peer-to-peer exchange affects the grid operation by DSO. They conclude that the increase of prosumption affects the dominant centralised design and functionality of the grid, increasing also the associated cost-of- service of DSO. For that reason, it is suggested that DSO should anticipate prosumption by providing additional services to neighbourhoods (vii & viii), which will require them to increase their managerial capabilities (iv).

Akinyele & Rayudu, (2016) introduce enabling strategies for developing energy systems in remote communities, with the aim of achieving sustainability. One of the main strategies suggested by these researchers is incorporate a "user-centred design" (viii). According to them, this requires changing the old approach of making users suit the system and make the system suit the users instead (vi).

Chen et al., (2020), perform a research to understand if it is possible for actors in the electric power value chain to improve innovation performance by implementing a BM with smart grid technologies. The analysis divides actors into demand-side and power-supply-side; for that reason the proposed BP are: a) For power supply side companies to focus on building a new transaction structure by establishing connections with new parties (ii), using new approaches to cooperate with trading partners (vi), or creating new trading patterns (v); and, b) For demand-side companies to reduce transaction costs or increase transaction speed by employing boundary-spanning activities (vi), to establish trading patterns (v), and to improve supply chains, and achieving information exchange (x).

González et al., (2017) aim at proposing a set of guidelines to promote sustainable development in a given region, considering all the stakeholders involved. The guidelines proposed by the researchers are divided into a) redesigning products in terms of customer needs (viii); b) redefining productivity in the value chain (vi); and, c) enabling the development of the local cluster (iv).

Pereira et al., (2018a) focus their research on the evolution of the electric power market and the related company adaptation needs. According to their findings, actors in the sector need to undergo strategic restructuring to support reallocation of assets and operations (ii), and mergers and acquisitions (i).

Mirzania et al., (2019), analyse the impact of new policies on community renewable energy (CRE) projects. Their results show that existing business model relies heavily on public subsidies, which are no longer favoured by regulatory schemes. Their proposition for CRE is to include battery storage in their business models of renewable energy; However, this type of model requires more technical and business expertise than existing CRE projects (iii). For that reason, they also suggest the creation of partnerships with intermediary organisations (vi) and greater cooperation between CRE groups (x).

Boait et al., (2019), report the results from testing a BM based on “smart home” technology. Their conclusion is that the sustainability of the transition to renewable energy can be strengthened with a community-oriented approach (viii) that supports users through technological change. Demand-response involves the change of behaviour from the user which, in the particular case of this BM is driven by technology.

Gsodam et al., (2015), investigate how electric utilities are changing their BM. Their conclusion is that new BM come in two different types: Utility-side and Customer-side BM. The first one suggests companies to try to cover the whole value chain or at least to expand their activities in the value chain (i); the second one to manage, own, and operate decentralized PV plants (iii) and seek cooperation with suppliers, project developers, or other utilities (vi).

Dilger et al., (2017), study the potential of crowdfunding for BM innovation. They conclude that co-operatives are not familiar with crowdfunding; however, the initiative has strong potential. They suggest local firms to open up to a broader group of members through equity-based crowdfunding (v).

Lehr, (2013a), carries out a research on new BM for utilities under a certain regulatory model. His conclusion is that utilities' BM need to become more servitized (vii) and establishes a series of attributes to achieve it. These include: a) Establishing a customer-oriented and entrepreneurial culture (viii); b) promoting flexible organization structure and internal cooperation (vi); c) facilitating processes; d) training personnel with customer orientation (viii); e)managing the co-existence of different BM (ix); and, f) allowing joint value creation with partners (x).

Helms, (2016), proposes a set of archetypes to create value in the electric power value chain. The outcome was 9 different archetypes for creating value in the local environment. In general, they propose a different structuration of the system to achieve servitization (vii) as well as a shift from tangible to intangible assets (ii & iv).

Hall & Roelich, (2016), aim their research at investigating the new opportunities that business model innovations are creating in electricity supply markets at subnational scale. They rely on more complex value propositions than the incumbent utility model and focus on expanding their capacities towards financial activities, so that value creation can come from financing schemes (v).

Wainstein & Bumpus, (2016), study BM as drivers of the low-carbon power system transition. Their paper shows that niche and regime actors of the system are involved in BM dynamics and that, in particular, new actors in DRE are achieving market scale by offering financially innovative BM (v) that do not require upfront costs from customers; they also state that firms need to see customers as part of their partnership network (viii).

Tayal & Rauland, (2017), investigate how Western Australian utilities can best adapt to the disruption of the market, and, in particular, explore how existing business models will need to evolve beyond traditional energy. From their conclusions, it is strongly advised that energy businesses in the local area should embrace the opportunities presented by emerging technologies such as solar PV and storage and do so in a modular approach (iii & vi). The aim of this is to minimise costs, retain customers and to have a gradual acquisition of capabilities.

Bolton & Hannon, (2016), examine the role of innovative business models, focusing on decentralised energy technologies in the context of a transition towards a more sustainable energy system. They pay particular attention to the figure of ESCOs, and suggest two possible future pathways for them ESCos in combination with DRE: a) The first BM enables local actors to become increasingly autonomous from the incumbent regime, through the development of localised infrastructure and markets (i & vi); and, b) is an alternative to the competitive/autonomous logic where the business model is more closely aligned with the existing market based logic of the system and more closely controlled by incumbent actors (x).

Huijben et al., (2016a) explore how the regulatory regime for Solar PV affects BM. Their findings suggest that the regulatory regime does not influence all components of the business model; for that reason, they suggest encouraging BM innovation in combination with technological innovation (iii). Organizational components of the BM are usually redesigned for this purpose (iv & vi).

Lehr, (2013a), carry out a research on how utilities adapt to a high-penetration renewable energy future. The author found three postures from which utilities can develop their BM; however, since the first one requires "no involvement" in RE market, only two are considered for this study: a) Utility 'smart integrator' or 'orchestrator', where the utility's role is one of facilitating technology and service changes but not necessarily providing all of them. Utilities would maintain their strong engineering and reliability standards but adapt and apply them to new technologies and service offerings (iii & vii). b) Energy services utility: This scenario sees utilities as "change agents" which is particularly challenging to develop given the fundamental notion of utility's abilities and incentives as less responsive and unmotivated to change (iv). This requires a more flexible organization (vi).

Shomali & Pinkse, (2016), seeks to explain under which conditions smart grid deployment will have an enabling or a constraining effect on electricity firms' engagement in business model innovation. From the analysis, some enabling and constraining factors of smart grids on incumbents' BM were found. Focusing these factors on value creation and delivery, researchers suggest that incumbents leverage on specialized ICT assets (ii & iii) or energy service providers; at the same time, they predict that the increased complexity of the value network requires them to adapt their organizational model (vi).

Bryant et al., (2018a), examined energy utilities' BM to understand their state in this changing sector. The researchers found 4 typologies of BM for utilities to incorporate RES generation in their offer. For their adoption, the suggested actions are: a) to build on existing value proposition, integrating a "green energy as a service" approach (vii); b) a more extreme opportunity is to shift entirely from a commodity-driven approach to offering an array of green, localised offerings available to customers, or to push a model of customer engagement and offer additional services via a ‘Prosumer Plus Utility’, ‘Smart Energy User Utility' or an "Off-grid facilitator" (iii, vi &viii); and, c) to entail a shift to a ‘Zero Carbon Supplier’, or ‘Local Area Energy Provider/Local Area Utility'.

Bauwens et al., (2016), analyse the factors likely to foster citizen and community participation as regards wind power cooperatives in four European countries. The findings of this research were that cooperatives not only adapt to externally imposed regulatory changes but also seek to actively shape these changes toward conditions more in line with their interests (vi).

Surie, (2017), investigates how social entrepreneurship, at both the firm and institutional levels, fosters innovation and economic development. The recommendations for fostering social entrepreneurship regarding RES are: a) direct collaboration with rural populations to serve their needs (viii); b) use of technological platforms to enhance interactions and diffuse skills (iii); and, c) collaborations with external organizations to enable acquisition of additional resources and capabilities (vi & x).

Khripko et al., (2017a), carry out a research to analyse opportunities for BM innovation through Demand-side Management in the RE industry. According to their findings, an implementation of such a BM needs: a) Adaptation in equipment (ii); b) focus on ICT and creation and communication to connect delivery (iii); c) Energy storage infrastructure (ii); d)Development of internal knowledge on energy market technologies (iii); and, e) Development of new collaborations in terms of pooling of capacities (vi).

Okkonen & Suhonen, (2010), examine the BM of small-scale heat energy production in Finland. They present different typologies of BM, such as Public utility company, public-private partnership, private company, cooperative, network model for a large company and energy saving company. The actions suggested for the development of these BM are: a) Designing a robust business architecture (ii); b) ensuring the availability of resources, including physical and human resources in the forms of physical capital, supply chain structure and supporting infrastructure (iv & vi).

Jolly et al., (2012), present a set of guidelines for upscaling a BM and increase its social impact; they are aimed at entrepreneurs in the solar off-grid market. Their conclusions are that there are 5 Dimensions for upscaling a BM: a) Quantitative: upscaling in terms of the number of beneficiaries; b) Organizational: upscaling in terms of expanding the capacity of existing business, i.e., developing resources, building a knowledge base, employing more people, or developing management systems (ii, iv); c) Geographical: upscaling in terms of regional expansion, i.e., serving more people in new regions and extending into new markets (viii); d) Deep: upscaling in the sense of achieving greater impact in an existing location, e.g., through reaching increasingly poorer segments of the population; e) Functional: upscaling in terms of developing new products and services (vii & ix).

The following table summarizes the New Function dimensions and sub-dimensions found in these papers.

Table 8. Dimensions for new functions

Source	New structure		New capabilities			New organizational model				
	External	Internal	Technical	Managerial	Financial	Flexibility	Servitiation	Customer-orientation	Co-existence of BM	Joint-benefit
	i	ii	iii	iv	v	vi	vii	viii	ix	x
Heaslip et al., (2016)						✓				
(Ahlgren Ode & Lagerstedt Wadin, 2019)								✓	✓	
Karlsson et al., (2019)		✓					✓			
Hellström et al., (2015)		✓								✓
Nair & Paulose, (2014)	✓			✓						
Specht & Madlener, (2019)		✓	✓			✓	✓			
Richter, (2013b)			✓	✓			✓	✓		
Hamelink & Opdenakker, (2019)		✓				✓				
Palit & Chaurey, (2011)					✓			✓		

	i	ii	iii	iv	v	vi	vii	viii	ix	x
Buitenhuis & Pearce, (2012)		√				√				√
Bellekom et al., (2016)				√			√	√		
Akinyele & Rayudu, (2016)						√		√		
Chen et al., (2020)		√			√	√				√
González et al., (2017)				√		√		√		
Pereira et al., (2018a)	√	√								
Mirzania et al., (2019)			√			√				√
Boait et al., (2019)								√		
Gsodam et al., (2015)	√		√			√				
Dilger et al., (2017)					√					
Helms, (2016)		√		√			√			
Hall & Roelich, (2016)					√					
Wainstein & Bumpus, (2016)					√			√		

	i	ii	iii	iv	v	vi	vii	viii	ix	x
Tayal & Rauland, (2017)			✓	✓						
Bolton & Hannon, (2016)	✓			✓						✓
Huijben et al., (2016a)			✓	✓		✓				
Lehr, (2013a)			✓	✓		✓	✓			
Shomali & Pinkse, (2016)		✓	✓			✓				
Bryant et al., (2018a)			✓				✓	✓		
(Bauwens et al., 2016)						✓				
(Surie, 2017)			✓			✓	✓			✓
Khripko et al., (2017a)		✓	✓			✓				
(Okkonen & Suhonen, 2010)		✓		✓		✓				
Jolly et al., (2012)		✓		✓			✓	✓	✓	

The last collaborative mechanism, *New actors*, was the least proposed by researchers in the analysed papers. In fact, only five papers included this approach. The following table summarizes the dimensions found.

Table 9. New Actor

Collaborative mechanism	Dimensions	Definition
New actor	1. Spin-off	For the implementation of the BM, an incumbent creates a new venture to manage the proposed activities.
	2. Start-up	The realization of the BM has/needs an entrepreneurial origin.

The proposition of creating a Spin-off was found in Richter, (2013a). He studies the opportunities and challenges that German utilities are facing when including electricity generation from renewable sources. The conclusion is that, despite having developed adequate organizational structures for utility-side projects, many utilities still lack business models for small-scale renewable electricity generation. Consequently, his proposition is for them to create separate ventures for establishing activities of the renewable energy industry.

The remaining four papers fall in the *start-up* dimension. Budde Christensen et al., (2012), seek to understand if innovative BM are a way to overcome barriers for a higher adoption of EV. The proposal of their BM is that consumers purchase an electric vehicle and sign a battery leasing contract with the focal company, which is a start-up. The firm provides the consumer with an installed infrastructure such as charging spots and automatic battery switch stations and manages the charging of the batteries. As the company itself is the "new actor in the system", they need to build the necessary infrastructure and create relationships for providing the service.

Hellström et al., (2015), aim to explore how firms in the energy industry adapt their BM to generate systemic changes in the industry. They study the case of a heat producer who is also a biofuel supplier; for improving their BM, the researchers propose them to increase their collaboration with a boiler manufacturer and, as a result of that collaboration, create a franchising model to offer to entrepreneurs.

Dehdashti, (2019), examines the transition from traditional energy generating systems to renewable resources. The proposition is a road-map for meeting the Green energy requirements of the electric power industry; the derived BM is an “Energy Bank”, which is proposed as a private entity that owns and/or operates a number of strategically located storage facilities and serves as a platform for physical storage and financial trade of electricity. It is, thus, a new actor in the electric power industry, that needs to build its own interactions.

Koirala et al., (2016a), analyses trends and key issues of energy communities. The proposed BM suggests the integration of a new actor in the system, which is called *Integrated community energy system* (ICESs). It supplies a local community with its energy requirements from high-efficiency co-generation or tri-generation as well as from renewable energy technologies coupled with energy storage solutions and demand-side management measures. This integration would have an impact in the system dynamics.

IV. Conclusion

This work proposed a framework for analysing the collaboration mechanisms for value creation in the renewable energy sector.

Value creation, in the context of renewable energies, is a boundary-spanning activity, i.e. it comes from collaborations between a focal firm and its stakeholders. From the SLR, these collaborations are divided into three mechanisms, nine dimensions and ten sub-dimensions.

In order to provide a concrete answer to the first RQ, the mechanisms that enable collaboration for sustainable value creation in the RE sector are: *Basic synergies, new functions* and *new actors.* The dimensions found as basic synergies are *purchasing, exploitation of a current asset or capability with a new purpose, extension of current activities or services*, and *co-planning of activities*; as new functions are *new structure, new capabilities* and *new organizational model*; and, as new actor the two dimensions are *spin-off* and *start-up.*

The only mechanism for which a series of sub-dimensions could be categorized was new functions: new *external* or *internal* structure; new *technical, managerial, financial* capabilities; and, new *servitization, customer-orientation* model, *co-existence of BM* or *joint-benefit.*

Overall, *Basic Synergies* imply that the focal firm does not need to make important changes to their current practices, since the collaborations can be covered by the same structure, knowledge and general activities performed by the firm. In this way, the collaborations work as an *extension* for sustainable value creation. From its four dimensions *Purchasing,* which, as its name states it, reduces the mechanism to a purchasing action, was the most used in the analysed BM.

The second mechanism, *New functions,* is not only the most complex in terms of structuring and sub-categorization, but also in amount of information included. These mechanisms represent an important change in the current practices of the focal company, which is necessary for it to collaborate with the selected actors. These changes can happen in three dimensions: a *structural* one, that is represented by a reorganization of the divisions or areas of the firm, including assets or even M&A; the second one, related to *acquisition of capabilities*, implies that the existent capacities and knowledge of the focal company are not enough for performing the desired collaborations, therefore, it needs to acquire them; finally, the third dimension refers to the implementation of a new *organization model* i.e. an adjustment in their business idea that allows the collaboration and subsequent activity for sustainable value creation. Still, these changes are within reach of the focal firm, i.e. they possess the ability to perform and control them.

Interestingly, most of the BM whose activities fell in this category, did not contain only one dimension, but a mixture of them. This implies that, for a focal firm, the adoption of new functions that enable collaborations generally comes in a bundle, which requires big efforts from their part.

From the ten proposed sub-dimensions, six were, by far, the most mentioned ones. The *internal* sub-dimension (1.ii) appeared in twelve propositions, new *technical* and *managerial capabilities* (2.iii & 2.iv) were suggested eleven times each, a higher *flexibility* (3.vi) was required in sixteen cases, while *servitization* and *customer orientation* (3.vii & 3.viii) were needed nine and ten times, respectively.

Finally, the last mechanism proposed in the framework, *New actors*, was found only in five papers. This mechanism proposes the creation of a new actor with capacities that current actors do not have to perform activities that they cannot perform. In three out of the five cases, the new actor was the focal firm itself, their BM was intended to ease collaborations among incumbents or take advantage of an existing gap. The other two cases were even more particular in the sense that the focal companies created a BM that needed a new figure to make it work.

The second RQ suggested that the perspective from which researchers analysed a BM might have an impact in the mechanisms proposed. As stated before, the correspondent finding established that the dimensions of each collaboration mechanism were consistent regardless of the level of analysis adopted in the papers. For that reason, it is reasonable to state that the answer to RQ 2, is that the level of analysis proposed by researchers does not have a relation with the mechanisms for collaboration that enable sustainable value creation.

Limitations

The main limitation of this work is that, although it presents a novel way of understanding collaboration mechanisms for value creation in the renewable energy sector, it does not build on the existing knowledge from new empirical evidence, nor is it constructed as a framework that can be followed for enabling collaboration of a focal firm with its ecosystem.

The reasons behind this, are mainly that the systematization of the different levels of collaboration was performed by studying in the literature existing or proposed BM and analysing the activities undertaken by a focal firm as a reaction to a set of conditions. However, the conditions and actions performed in return by the other actors involved in the system do not form part of this framework. This is a critical aspect when shaping a sustainable ecosystem in practical conditions, otherwise, the flow of knowledge and integration of the BM can be seriously compromised.

Additionally, there are a series of other variables that can have an impact on the decisional process of a company, regarding their behaviour as an actor of a given system. Apart from other actors, namely suppliers, customers, universities/ research centres, government institutions and other organizations in general, there are other aspects that shape the context of a firm for stablishing a strategy such as the social environment, cultural characteristics or regulatory framework. It was observed that these aspects were considered by researchers for the selection of their level perspective, or mentioned as barriers or limitations for the implementation of a BM. In any case, they were not considered for analysing the dimensions proposed in the framework.

The regulatory framework was seen by some researchers as “limits” to their innovative solutions, but others considered them as “starting points”, as if it were a white canvas from which they could start creating something.

The case of the context of the BM is different and there are reasons to believe that, if analysed closely, some other insights of their impact and importance for the understanding of collaboration mechanisms could be obtained. This statement comes from the perception that there was a distinction in the proposition of collaborations depending on the socioeconomic context of the BM; in other words, the relationships formed by focal firms in rural areas or communities with little or unreliable grid infrastructure seemed to have a different tendency from the ones of companies stablished in more mature markets.

Another factor that was not integrated for the categorization of collaboration mechanisms was the level of success or effectiveness of the BM. This aspect was acknowledged when the research by Christensen et al., (2012), was being analysed, as it contained a very well-known BM of a battery leasing company for EV. This case has been repeatedly referenced by researchers for its innovative approach to some of the barriers that were preventing BEV from becoming more widespread in the market, yet it is mainly mentioned for the reason that their proposition was unsuccessful. It might be important to consider this parameter in the future since, as Richter, (2013b) states, any kind of sustainable benefit that comes from innovation remains latent until it is successfully commercialized through a business model.

Practical implications

As it has been stated before, the realization of the present work derived in a theoretical framework for analysing a known phenomenon from a new perspective; however, this does not imply that it does not have any practical implications for some of the actors involved in the renewable energy industry. The following section aims at highlighting a few remarks that could be useful in practice.

The first implication addresses strategic managers. Collaborations among firms and other stakeholders are a reality, particularly in a networked sector such as the energetic one. A company's strategy and its related BM should not be planned without considering the ecosystem they perform in and without previously analysing if the firm would need to adapt in some way for its performance as part of such ecosystem. In addition to that, these possible adaptations should be analysed in terms of the disposition of the firm itself: Would it be willing to perform the necessary internal changes?

Another important takeaway is that having adaptation capacities is crucial. As seen from the results, the new functions that were mostly sought after in the BM were for companies to acquire new capabilities (technical and managerial) or increase their organizational flexibility. These factors challenge the old vision of companies, especially large ones, as unchanging entities with fixed offerings and processes.

One particular case was the one of financial capabilities. Three of the five papers that suggested firms should acquire that kind of capacities, involved participating in rural communities and their BM had a noticeable social objective. This is an example of the importance of considering the user's context when defining a business strategy.

Although it was not one of the main actors analysed in the present work, there was a recurrent mentioning of policy makers and authorities; however, most of the papers focused on the limitations imposed by existing frameworks, and a couple of them even mentioned that policy makers were not keeping up with the evolving energy ecosystem. In such case, as policies are given, the suggestion is to know the limits imposed by the context a firm is performing in, but, at the same time, to be prepared for changes which can either limit further or add degrees of freedom for a BM.

Future research

Having stated that the sustainable value creation comes from the collaborations among actors of a system, a next interesting research step could be to understand how value capture works in such collaborations. A possibility comes from the fact that value capture is deeply related to the economic sustainability of a firm, without which a BM would not be feasible in the first place. Another interesting perspective could be taken if we consider the focal firm as a "business integrator" for all its ecosystem; in such case, analysing the benefits obtained by the non-focal firms could present a deeper understanding of how collaboration networks really work.

Additionally, a new perspective could be used for understanding the effectiveness of collaboration mechanisms if they were tested in relation to firm performance. Apparently, enabling innovative mechanisms for collaboration, does not necessarily imply that a firm would perform better, since the link between innovation and firm performance is not straightforward (Hamelink & Opdenakker, 2019).

Finally, given that this work could not find a real correlation between the level of analysis chosen by researchers and the selection of mechanisms for collaboration (RQ 2), Huybrechts' theory, (2014) could be re-taken with the aim of studying systemic change towards sustainability , rather than only levels of analysis. In other words, a new analysis could shed light into understanding if the level of analysis defined by researchers is correlated to how close the BM proposition is to reaching sustainability at system level.

These ideas give way to a possible future research agenda on the variables presented in this framework.

Table 10. Future research

Framework variables	Possible research questions
Level of analysis of a BM	Does the level of analysis have a correlation to how close a BM is to achieving sustainability at a system level?
Mechanisms for collaboration	How do firms that are part of a collaboration network for sustainable value creation capture value? Is value capture limited to economic measures or do companies benefit from other sources? How much does a firm performance depend on innovative collaboration mechanisms if at all?

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