Renewable and Sustainable Energy Reviews 144 (2021) 111013

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: http://www.elsevier.com/locate/rser

Business models for energy communities: A review of key issues and trends

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ARTICLE INFO

Keywords:
Energy communities
Business models archetypes
Business model canvas
Lean canvas
Value proposition

ABSTRACT

The 'Clean Energy for All Europeans' legislative package places citizens and communities at the heart of the European energy policy by promoting local energy generation, consumption and trading. As only recently energy communities were formally defined in the European regulatory framework, the literature on energy community business models is still scattered and a clear systematization of community arrangements is missing. This paper aims to provide a comprehensive view of the prevailing and emergent energy communities business models, focusing on the value proposition offered by these initiatives. Community projects across Europe are analyzed and eight community business model archetypes are identified having the current European regulatory framework as background. The Business Model Canvas and the Lean Canvas frameworks are used to characterize and compare these archetypes. The main differences between business models are examined to highlight the most relevant strengths and barriers for energy community development. This analysis revealed the dominance of traditional self-consumption place-based communities, while business models involving differentiated services as demand flexibility, aggregation, energy efficiency and electric mobility are still scarce. However, the research around novel business models must be strengthened as they are expected to become crucial in upholding energy communities as key players in the energy transition and foster the regulatory framework evolution.

1. Introduction

The European Union's (EU) long-term climate-neutrality targets require that by 2050 at least 75% of the total energy demand comes from renewable sources and around 16% of the electricity generation has its origins in collective projects [1,2]. By that date, almost half of all European households must be involved in renewable energy generation, 37% of which should be engaged in collective projects [2,3]. To achieve these ambitious targets, a structural transformation of the power sector is required, moving towards decentralized renewable-based systems in which citizens are directly involved in energy consumption, generation, trading and supply activities [4]. In this setting, energy communities are gaining increasing relevance, being perceived as cornerstones for a successful energy transition [5,6]. Energy communities have the potential to change the energy landscape by empowering consumers, contributing to energy and climate goals regarding demand satisfied by renewable sources and emissions decrease. Moreover, they promote collaborative social transformation by leading local communities to pursue common goals (e.g. energy costs reduction and energy self-sufficiency) [7]. Energy communities can also play a relevant role in local economic growth and job creation, boosting smart grid infrastructures and providing valuable flexibility services to be traded in emerging markets, thus speeding up the transition to a low-carbon economy [8].

Community-driven energy projects have been part of the EU's energy landscape for many decades [9]. North-Western Europe countries are pioneers in implementing community initiatives due to national policies designed to enable citizen-led decentralized renewable energy projects [10,11]. The long-lasting tradition of renewable-based community projects organized as cooperatives in these countries is explained by the need to solve supply issues (electricity and heat) in rural and isolated areas and has led to a high presence of renewable generation coming from hydro, biomass, solar photovoltaic (PV) and wind technologies [10,12]. In the United States, energy co-ops (or collective solar models, as they are generally based on PV), the local designation for energy cooperatives, are already responsible for generating about 11% of the total power sold in the country and also playing a key role in the electrification of low density areas [13–15]. Other countries, as the United Kingdom, also started to promote local self-consumption projects,

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https://doi.org/10.1016/j.rser.2021.111013
Received 12 October 2020; Received in revised form 1 March 2021; Accepted 19 March 2021
Available online 7 April 2021
1364-0321/

List of abbreviations

BM	Business models
BMC	Business model canvas
CEC	Citizen energy communities
DSM	Demand-side management
DSO	Distribution system operator
EBM	Energy business models
ECBM	Energy community business model
EE	Energy efficiency
ESCO	Energy services companies
EU	European Union
EV	Electric vehicles
HEMS	Home energy management system
ICT	Information and communication technologies
IEMD	Internal electricity market directive
LC	Lean canvas
LEM	Local energy markets
P2P	Peer-to-peer
PV	Photovoltaic systems
REC	Renewable energy communities
RED-II	Renewable energy directive
PPA	Public purchase agreement
SMEs	Small and medium-sized enterprises

largely encouraged by feed-in-tariff schemes, which encouraged the private investment in renewable generation [12,13].

European energy policies are moving away from incentivized programs, aiming to untap private funding without which the energy system transition goals cannot be achieved. To this end, energy communities and collective self-consumption initiatives, brought to the center of the European energy policy by the recast of the Renewable Energy Directive (RED-II) (2018/2001/EU) [16] and the common rules for the Internal Electricity Market Directive (IEMD) (2019/944/EU) [17], can play a key role. In 2018, the RED-II introduced for the first time a definition for energy communities, proposing a regulatory framework for "renewable energy communities" (REC). RED-II rules are embedded in the IEMD, which only entered into force in 2019, proposing a broader definition of "citizens energy communities" (CEC). Both definitions describe energy communities as non-commercial legal entities, based on the open and voluntary participation of their members, which can be households, public authorities and small and medium-sized enterprises (SMEs), provided their main activity is not energy-related [16,17]. Community members must be fully or partly involved in daily decision-making and operation control, and the potential revenues attained must be used to provide local services/benefits. However, those definitions diverge in what concerns [16,17]:

- the **geographical scope**, since REC require participants to be in the vicinity of renewable projects, while CEC does not set physical boundaries;
- the **activities** performed, as CEC comprise generation, distribution, supply, consumption, aggregation, energy storage, electric vehicles (EV) charging, energy efficiency (EE) or other energy services, while REC promote the engagement into generation, trading, storage and supply of energy from renewable sources;
- the generation **technologies**, since REC only allow renewable technologies whereas CEC are technology-neutral, meaning that both renewable and fossil-based technologies are acceptable; and
- the **membership** rules, as CEC consent large companies to participate as members or shareholders as long as their business is not energy-related, contrarily to REC. This distinction allows communities to be fully controlled by small end-users aiming to benefit from renewable energy or to be deployed in partnership with commercial stakeholders or social entrepreneurs (shared ownership models [18,19]).

Currently, both legal definitions of energy communities coexist under the same legislative package. However, whereas CEC definition aims to set the role for energy communities in the energy market framework, REC focus on supporting the deployment of renewable energy resources. Member-States are now faced with the task of transposing both directives into national laws, shaping them according to national realities and ensuring that the necessary conditions for the development of energy communities are met by mitigating existing regulatory, technical and financial barriers. Therefore, the enabling framework fostered by both directives is expected to boost innovative business models (BM) and attract private and public investment, allowing energy communities to become increasingly commercial, to diversify their revenue streams by proposing novel energy services in addition to local energy generation, while intermediating entities, alliances, and collaborative relationships among initiatives are promoted [20,21].

Although establishing a first step towards harmonizing what is meant by energy community, the definitions presented by the directives are somewhat vague, regarding the concept and implementation [22]. If, on the one hand, this wide scope definitions may provide the adaptability required to adjust energy communities to different national contexts [23] and to boost innovation [24], on the other, the door is open for the concepts to be used inappropriately, at the risk of missing the sustainable community development and energy democracy goals [25]. Thus, compromise solutions can be achieved by adjusting the broad definitions to specific contexts (by defining the actors, the legal structure, the voting rights, the scale, etc.) and motivations (by stating who benefits from the project and how) [22,26]. Therefore, in the scope of this work, energy communities must be understood as locally and collectively organized energy systems, encompassing the concepts of sustainable energy communities [27], community energy [26,28], community microgrid [29], community-based virtual power plant [30] and prosumer-community groups [31]). In our vision, energy communities may be engaged in all the energy-related activities announced by RED-II and IEMD, implemented mainly within, but not restricted to, a specific geographic area. No technology restrictions are considered, although renewable generation must be privileged and smart-grid infrastructures, as well as storage devices, are promoted as a way of allowing the development of differentiated energy services and the exploitation of demand flexibility. These arrangements are characterized by the participation of residential and non-residential members (local authorities and small businesses), who are willing to work collaboratively to reach common goals and must be at the center of the decision-making processes, even if the investment and infrastructure ownership belongs to other stakeholders. Regardless of whether they are run for commercial purposes or not, the main aim of energy community projects must be to fulfill the energy needs of local communities, allowing them to reach some degree of energy autonomy by optimally managing their resources, while delivering social and environmental benefits. In this sense, this definition encompasses energy communities as place- and interest-based models (depending if members join due to geographical proximity - communities of place - or common interests, goals or passions - communities of interest [32]), driven by not-only-for-profit goals, with democratic and shared ownership and organization rules, narrowing the scope of the European definitions to a more specific context and motivation.

According to our vision, energy communities are perceived as bottom-up energy-related projects driven towards local needs, characterized by strong citizen participation, local ownership, decision-making with a single vote per actor and sharing of collective benefits [33]. However, drawing on the Devine-Wright distinction between 'energy community' and 'community energy' [33], the energy community concept goes much further. First, energy communities promote the establishment of partnerships with entities from other sectors that bring technical and business development expertise, maintaining a strong focus on private and local investment. In turn, community energy projects are dependent on financial and technical volunteering. Second, energy communities encourage the participation of users owning smart technologies (e.g., smart metering, home energy management systems (HEMS), etc.) and aspire to take advantage of these devices to optimize their choices to the detriment of participants merely motivated by environmental, social and economic issues. Third, energy communities go beyond community energy goals by also promoting economic growth, job creation and the development of smart and renewable technologies.

So far, few studies have addressed community-centered BM. For instance Ref. [6], defined "renewable energy clusters" and analyzed "regulatory sandboxes" for energy communities creation, without exploiting the underlying BM. In Ref. [13], the evolution of energy communities in England was reviewed and three BM archetypes were identified based on grant funding, feed-in-tariffs and incentives, and long-term agreements to build large community projects. In turn [20], proposed local energy archetypes, although the more innovative BM[1] are hypothetical. Four energy community BM (ECBM) were also proposed by Ref. [34], namely: 1) cooperative investment, based on citizens paying fixed membership fees or variable stakes to become members of communities acting as energy producers; 2) energy sharing, based on the allocation of surplus energy among community members; 3) aggregation, based on providing flexibility to different system operators; and 4) microgrids, based on communities capable of fully operating their distribution grid autonomous from the power grid. Though, these archetypes do not cover all the possible activities left open by the European directives, such as electric mobility (e-mobility) or EE.

This paper aims to review and systematize ECBM archetypes, comprehensively covering all the legal forms and governance models announced in the European directives [16,17]. Following [20,35], an 'archetype' refers to a generic form of a BM. The design of the archetypes is intended to better frame the discussion of BM and organizational structures in community settings. We have examined peer-reviewed literature on energy business models (EBM) focusing on electricity as the main energy vector, since it is a common element in both directives. Thus, henceforth the term 'energy' refers to 'electricity', unless further specification is provided. Drawing on Osterwalder and Pigneur's definition of BM [36], the Business Model Canvas (BMC) is used to fully describe and compare the main dimensions of ECBM derived from the literature since it helps to better understanding existing BM. The Lean Canvas (LC) framework is also used to further identify the market challenges and proposed solutions offered by each BM archetype. The combination of both BM frameworks provides a comprehensive set of boxes and tasks that help to visualize and conceptualize the BM, shedding light on their main strengths and weaknesses, facilitating the analysis of decision-makers. Ultimately, this paper aims to provide a comprehensive framework to policymakers and business managers regarding BM opportunities and uncover the main barriers they may face, helping to develop better regulatory and business backgrounds.

The remaining paper is organized as follows. Section 2 presents the conceptual background regarding BM, introducing the BMC and the LC frameworks, and examining the most common EBM derived from the literature. In Section 3, the adopted methodology is described and in Section 4 the several BM archetypes considered in community initiatives are described in light of the BMC and LC frameworks. Lastly, in Section 5, the main drivers, barriers and policy implications for energy community models are discussed. The paper finishes by presenting a summary of the main conclusions, leaving hints for future research.

2. Literature review

2.1. Business models frameworks

The BM concept roots back to the mid-20th century but has only received attention in the middle of the 1990s due to the emergence of internet-based business activities [37,38]. Despite the common use of the concept since then, there is still no agreed definition in the literature [37]. Many authors, as [39], argue that a BM must answer the four basic questions enunciated by Drucker [40], namely: "*Who are the customers? What is valuable for them? How does the company make money from the business? How can value be provided to customers at an appropriate cost level?*". Others have emphasized that a BM describes the logic behind a business operation, describing how companies allocate their activities and resources (investments) to reach profits [38]. In a simple way, a BM defines how organizations can create, deliver and capture value [36].

In order to summarize all the dimensions involved in the BM concept [36], proposed a systematic approach for BM creation – the BM generation technique - improving the method previously developed by Ref. [41]. This technique offers a useful framework to assess existing and new BM, considering the company side and the business environment, being visually presented as a canvas - the BMC [36] (Fig. 1). It entails nine building blocks, each representing a specific business dimension whose positioning in the canvas aims to set a guide for the BM design [36,38,42]. The four blocks located on the canvas left side ('key activities', 'key resources', 'key partners' and 'costs structure') focus on how value is effectively created. The 'value proposition' block divides the canvas, highlighting the value created from the customers' point of view. In turn, the remaining four blocks aim to identify how value can be delivered and captured.

Despite the flexibility and strengths of this approach, some authors highlight certain BMC limitations, as the weak representation of relationships among businesses elements, thus failing to show strategic dimensions such as the companies' competitive position [42,43], or the little detail presented due to the canvas structured template, responsible for compromising creativity and the unveiling of other business dimensions [44]. These weaknesses do not seem to affect the growing application of the BMC, which remains the most widely used approach for business description. Therefore, it will be used in the scope of this work to assess and compare the BM in energy communities.

Bearing in mind the criticisms of BMC, the authors in Ref. [45] developed the LC framework (Fig. 1). The LC is an action-oriented method to further understand the costumers' problems, highlighting the BM competitive advantage and risks [45]. The LC can be defined as a tool for testing and validating the BM hypothesis, expanding the scope of the BMC and focusing on market problems and solutions, instead of concentrating efforts on identifying relationships and partnership strategies [46,47]. The LC builds its structure on the BMC and replaces some of its blocks. The BMC 'key partners' block is replaced by the 'problem' block, aiming to clearly identify the customers' problems justifying the need for a new product/technology [47]. After presenting the problem, the solution is proposed in the 'solution' block, which replaces the BMC 'key activities' block. A 'key metrics' block is included to keep a record of the most important operation elements, allowing to examine the BM performance by defining a set of observable indicators [47]. An 'unfair advantage' block (or 'competitive advantage' block [46]) is included to identify the obstacles preventing competing companies entering the market [47]. The 'key resources' and 'customer relationships' blocks are removed from the LC as they are indirectly presented in the 'key

[1] In the scope of this work, the concept of 'innovative' business models is used to refer to theoretical models which are still very scarcely exploited in real applications since they usually involve: high levels of technology and information and communication infrastructures (ICT), the enrolment of new market operators and the change of the roles played by traditional market operators.

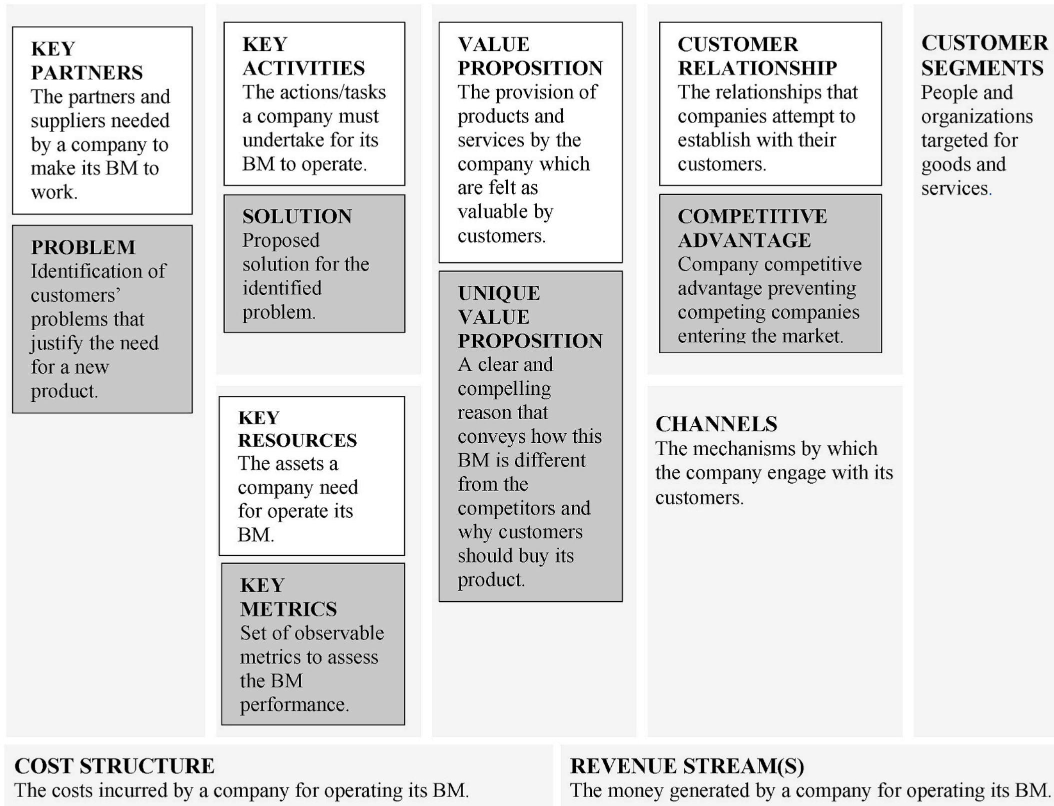

Fig. 1. BMC and LC structures [36,45]. Legend: white text boxes: BMC blocks; gray text boxes: LC blocks; no frame boxes: common blocks.

metrics', 'unfair advantage' and 'channels' blocks [46,47].

In the BM literature, several assessment frameworks have been proposed. The BMC is used as it is the most popular BM assessment framework and focus on the business key activities required to generate value and revenue, while encouraging strategic relationships. Due to its comprehensiveness, it provides a tool that helps to reshape the business at any time. In turn, by expanding the BMC, the LC better addresses the risk that involves recent BM, focusing on concrete market problems, encouraging simple and testable solutions and proposing key metrics. Thus, by combining these two BM techniques, existing and novel ECBM can be examined and compared through a wide range of predefined blocks representing core BM dimensions.

2.2. Energy business models

Before the energy market liberalization, little attention was paid to EBM since the monopolistic utilities' value proposition was based on providing an undifferentiated commodity to a broad segment of customers [48,49]. Market unbundling alongside the increase of renewable-based decentralized generation have imposed changes on the classical utilities BM, allowing smaller energy retailers to develop and offer innovative electricity supply packages, opening room for new EBM to emerge [48,49]. EBM tend to be primarily service-oriented, providing electricity supply, energy management, EE services, etc. and big utilities and small energy retailers currently strive for offering competitive and customized energy solutions increasingly focused on local generation and consumption [48,50].

Several studies have addressed EBM over different perspectives. For instance Refs. [15,51], reviewed EBM centered in demand-side management (DSM) and EE services from the system operator point of view. Authors as [18,19] focused their research on how energy service companies (ESCO) create value, while [52] highlighted how e-mobility services can be exploited from a business perspective. Also, BM involved in prosumerism[2] were addressed by Ref. [35], while [53] reviewed the evolution of PV-based BM. More recently, studies addressing local energy initiatives, as [6,20], and municipal governance models [54], have started to propose BM for collective settings. However, the study of ECBM are still in its early stages of development and a comprehensive picture of the existing and emerging BM is missing in the literature [47]. Additionally, despite studies as [20,50,55] have proposed different classification frameworks for EBM, a standardized classification is still missing [47]. The existing approaches are quite dependent on specific applications and the authors' perspective on the classification focus, which is usually based on assets ownership, giving rise to two generic BM: the customer-side and the third-party-side EBM. More recently, a third generic BM, focused on the services provided (instead of the investment and assets ownership), has emerged to describe the activities exploited in collective initiatives [50].

2.2.1. Customer-side business models

Customer-side BM (also denominated as customer-owned product-centered [50], prosumer BM [55], plug and play [56], host-owned [57] or customer-owned PV [58]) are based on the direct purchase of energy technologies by end-users, who aim to become prosumers/prosumagers or take advantage of DSM programs. Prosumerism BM [55] are initiated by customers who invest in energy generation and storage assets to benefit from self-consumption and energy bill reductions. Longstanding

[2] Prosumerism (or prosumagerism if storage is involved) is based on distributed energy resources generation activities developed by individual or aggregated households, commercial entities or industrial facilities, which become simultaneously energy consumers and producers [35].

power purchase agreements (PPA) are established with energy retailers or last resort traders, which buy the prosumers' generation surplus and remunerate them through feed-in-tariffs,[3] while providing the upstream power requested [35,47,59]. The '*all sold to the grid*' or '*self-consumption with surplus sold to the grid*' modes may be exploited, allowing the full injection of the generated power into the grid or self-consumption and surplus injection, respectively [50]. Solar PV and micro wind turbines are the most exploited technologies for prosumership, with installed capacities ranging from a few kW to about 1 MW [47]. In turn, if BM are exploited for taking advantage of demand flexibility by shifting demand from electricity peak hours to other periods in response to price signals, end-users must invest in DSM enabling devices (e.g. HEMS, smart meters, monitoring devices, etc.) [51]. These BM (also designated as customer-owned DSM BM [50,55]), are often implemented by prosumers aiming to optimize the combination of their energy resources [52].

Customer-side BM are characterized by high up-front costs and long-term payback periods. Consequently, homeowners and SMEs, who have the financial capability (or are able to access financing sources as bank loans or incentive programs), the needed conditions to install onsite generation systems (e.g. available rooftop area for solar PV) and the demand flexibility to take advantage of DSM programs, the 'key resources' of these BM, are included in the 'customers segment' [50]. The relationships between customers and business 'key partners' as technology providers, energy suppliers, distribution system operators (DSO) and bank entities (if loans are involved), are based on direct communication channels through salesmen, client support platforms and technical staff, which usually interact directly with customers to advertise new products, offerings, exhibit new customized solutions and solve technical and customers' issues. Due to their specificities, the 'key activities' of these two customer-side BM streams are different (local energy generation, self-consumption and selling versus changing consumption patterns), but the 'value proposition' is quite similar - to reduce customers' energy costs by self-consuming and selling power and to compensate them for participating in DR programs. The 'cost structure' and the 'revenues streams' are also different. In prosumerism BM, assets purchase, installation, reparation and maintenance and grid interconnection costs are included, and prosumers are expected to return their investments by selling their surplus generated electricity. In turn, in customer-owned DSM BM, smaller costs are involved as the required DSM enabling devices are usually cheap and customers investing in such BM expect to be financially compensated by the savings reached by changing their electricity utilization patterns. The BMC of customer-side BM is displayed in Fig. 2.

2.2.2. *Third-party-side business models*

The value proposition of third-party-side BM (third-party service centered BM [50], third-party-owned BM [46] or utility-side BM [55]) is the removal of the upfront costs for end-users, since these BM are fully financed by third-party companies, generally utilities, which keep the assets control and ownership and bear all the related costs and risks. In turn, for the investing companies, the key value proposition of such BM is the creation of valuable energy services and remuneration streams.

As customer-side BM, these BM can also be exploited for providing different services. The most common is renewable energy supply (third-party ownership BM [57], company-driven BM [56], or third-party for renewable technologies BM [50]). Renewable generation assets are installed either on customers' roofs and backyards or in the vicinity of consumption sites when space is constrained [55]. Households, SMEs and industrial facilities aiming to consume renewable electricity are especially targeted by these BM and as the distribution from generation to consumption sites must be ensured, DSO must be involved as 'key partners' [14,57]. The companies financing these BM usually own several small-scale generation units located away from each other and operate them as virtual power plants, centralizing the management of their energy resources [35]. When utilities are not the investing companies, partnerships with licensed suppliers can be established giving rise to 'local white label suppliers' [20,50]. Third-party-side BM can also be implemented to deliver DSM-based services. From the investing company perspective, the goal is to aggregate customers' demand flexibility and sell it to a system operator, assuming the role of an independent aggregator (local aggregator BM [50]) [51]. Thus, the company must develop DSM strategies and signing agreements with customers, who commit to deliver pre-defined energy/power amounts, which are then sold to system operators in reserve, balancing and ancillary markets [50]. Lastly, third-party-side BM can also be established to provide EE services (including energy audits, provision of services as space heating, lighting, etc.) giving rise to ESCO. ESCO deliver services on a turn-key basis and may either operate under energy supply contracting (committing to reduce customers' final energy demand by providing services as electricity, heat or steam and being remunerated for the useful energy output) or energy performance contracting (by implementing EE projects and being compensated by the stream of income from customers' savings) [50,60].

Residential neighborhoods, large companies and industrial parks aiming to benefit from customized energy supply solutions and EE services are targeted by these BM. Technology providers (such as PV, storage and efficient appliances sellers and manufacturers of smart metering and ICT-based devices, etc.), technical staff and power system entities (such as DSO), are involved as 'key-partners' in all the 'key activities' required to provide energy supply, EE and demand flexibility aggregation services. The relationships between the involved parties are, therefore, settled through direct communication channels, which may include customer support services, technical staff or other means (as marketing campaigns, face-to-face meetings, etc.). Long-term contracts (either PPA or leasing contracts) signed between customers and the investing companies are the basis of the 'revenues streams' of these BM, which ensure that prices and conditions remain competitive and stable over the project extension [46].The 'key resources' the company needs to maintain, the 'cost structure' and the 'revenue streams' are highly dependent on the services provided as typically more financial and technical resources are required to provide energy supply services [46]. The level of involvement of the company, which can develop their own technologies or buy them from third parties, also influences significantly the companies 'key resources' as well as the 'costs structure', since it can either include the costs of research, design, development and assembling of technologies or the costs of purchasing those technologies and operate them. Additionally, market studies, marketing strategies and the costs of using distribution networks, must be considered depending on the specific BM segment.

The BMC of third-party-side BM is presented in Fig. 3.

2.2.3. *Energy community business models*

Community-shared BM [47] or ECBM [46,50,61] have been created by proactive citizen groups striving to decide how their energy is generated. Backing to collective energy projects roots, reinforced by RED-II and IEMD, community members must be financially involved and the whole BM must be created by, for and with them [30]. Therefore, members should be considered in the overall arrangement design, implementation and operation, influencing how the ECBM value is generated and the risks and costs are shared [30,62]. Given the amounts of investment required, external financial involvement is also possible through different types of partnerships. Thus, from the investment and assets ownership perspective, ECBM can be categorized under the label of the customer-side BM and/or the third-party-side BM, since both, as

[3] It is assumed that these contracts guarantee to prosumers the disposal of their energy through retailers or last resort traders. Occasionally, the electrical system may not be able to drain the energy generated by distributed resources due to imbalances between demand and injection. In these situations, prosumers may not be remunerated by surplus injection.

KEY PARTNERS
● Technology suppliers.
● Energy suppliers.
● Banks and financing organizations.
● DSO.

KEY ACTIVITIES
● Electricity generation.
● DSM actions.

KEY RESOURCES
● Private investment.
● Physical conditions.
● Demand flexible appliances.
● Technical resources.
● Distribution network capability.

VALUE PROPOSITION
● Renewable electricity generation and DSM services.
● Reduced electricity bills.
● Environmental value.
● Financial compensations for participation in demand response (DR) events.

CUSTOMER RELATIONSHIPS
● Direct interactions.

CHANNELS
● Salesmen.
● Technical staff.
● Home exhibitions and other information strategies.

CUSTOMER SEGMENTS
● High and regular-income households.
● SMEs.

COST STRUCTURE
● Up-front investment in systems.
● Installation, repair and maintenance expenses.
● Costs for grid interconnection.

REVENUE STREAM(S)
● Surplus generated electricity (to the grid or to other users) sell and self-consumption.
● Savings from implementing DSM actions.
● Payment from DR aggregator and other system operators for providing demand flexibility.
● Remuneration through feed-in-tariffs.

Fig. 2. Customer-side BMC.

KEY PARTNERS
● Technology suppliers.
● Technical staff.
● Power systems entities.

KEY ACTIVITIES
● Energy supply, EE and DSM services.
● Operation, management and maintenance.
● Marketing activities.
● Aggregation of customers demand flexibility.

KEY RESOURCES
● Companies financial and technical resources.
● Customers.

VALUE PROPOSITION
To customers:
● Eliminate upfront costs.
● Eliminate technical issues.
● Environmental value.
To investing companies:
● Increase customers portfolio.
● Provide energy services.

CUSTOMER RELATIONSHIPS
● Long-term contracts.

CHANNELS
● Customer services.
● Technical staff.
● Online and offline marketing strategies.

CUSTOMER SEGMENTS
● Industrial parks and large companies.
● Neighborhoods and communities.

COST STRUCTURE
● Construction, purchase, installation, repair and maintenance costs.
● Reinvestment costs to maintain, improve and increase installed capacity.
● Marketing and new customers recruitment costs.
● Payments for remunerating customers demand flexibility.

REVENUE STREAM(S)
● PPA and assets lease.
● Government subsidies.
● Energy supply and services selling.
● Sell of demand flexibility in ancillary and flexibility markets.

Fig. 3. Third-party-side BMC.

well as hybrid forms, are possible.

Although energy communities are not primarily run for profit, ECBM must guarantee their shareholders the return of their investment by benefiting from cheaper energy supply, selling surplus generation or participation shares, or by self-consuming and thereby reducing their power grid dependency [34,63]. Some studies, as [64], revealed that the return on investment is one of the most important determinants for community shareholders to enroll in such initiatives. However, the value proposition of energy communities goes far beyond the economic dimension [22,30]. The environmental contribution due to renewable energy generation, the ability to choose the technologies to generate energy, the social innovation created by shifting the role played by consumers, who become customers, asset owners and company shareholders, are also relevant value propositions of ECBM [8]. Also, by joining a community, all the costs and risks are shared, removing the high upfront cost barrier [5].

As announced by the European directives, ECBM 'key activities' include local generation, supply, storage, consumption, trading, aggregation, e-mobility and energy related services, as well as system administration. 'Key resources' include: the members, due to the social and financial value they bring to the projects; the available area for implementing generation and storage facilities; the financing resources to implement and manage the project (either from members and partners); and technical know-how, which can be outsourced (in this case, outsourcing costs must be considered in the 'cost structure'). The availability of incentives for renewable energy producers, as well as enabling regulatory frameworks, can also be understood as key resources for the operationalization of such initiatives. Households, SMEs and public entities, which constitute the 'customers segment' are also 'key partners' alongside technology suppliers, external investors, DSO, energy suppliers and other power system entities (as aggregators). Since, in most communities, participants are both involved as customers and business developers (except for projects financed by third-parties), the 'customers relationships' and the communication 'channels' are personal and direct. The 'costs structure' of these BM must comprise: the costs of performing technical and economic feasibility studies to examine the viability of the community project; the planning and licensing costs; the capital costs of building and installing generation, storage, management and distribution assets; the costs for using the public distribution network; the reinvestment costs to improve and expand the existing infrastructure during the projects life time beyond the costs incurred to operate and manage the infrastructure. Also, if the energy community project is not able to fulfill the energy needs of their members, energy procurement costs must be considered. The 'revenue streams' come from the sale of participation shares (shareholding mechanisms allow communities to be flexible to the entry and exit of members, without compromising the participation of the remaining ones [65]), energy contracts with suppliers or other external entities to whom the surplus generation or other energy services is sold, and subsidies or other long-term contracts between the government and renewable energy producers. The BMC of an ECBM is displayed in Fig. 4.

Most energy communities have been primarily involved in local generation and self-consumption due to the longstanding tradition of these initiatives in Northern Europe countries [66]. More recently, the evolution of ICT-based infrastructures and energy exchange platforms boosted selling and sharing activities in collective settings, allowing to optimize the utilization of local energy resources, to maximize the community members' economic benefits and underpin the deployment of local energy markets (LEM) [67–69]. In addition, the IEMD opens room for Member-States to grant communities the right to own, establish, purchase or lease the distribution network in their area of operation [17]. Energy communities may, therefore, become local DSO, under the general or the 'closed distribution system operator' regime, meaning that the community become responsible for: "*ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity, for operating, maintaining and developing under economic conditions a secure, reliable and efficient electricity distribution system in its area with due regard for the environment and energy efficiency*." [17]. By owning and operating their internal distribution network, energy communities gain power over the prices charged to customers and may implement targeted DSM actions, giving rise to BM aimed at demand flexibility management [63]. The deployment of customized DSM strategies allows energy communities to aspire to be self-sufficient from the power grid by balancing local demand and supply, which may be easier in fossil-fueled CEC than in REC, since the dispatchable supply-side can be adjusted according to the community power demand. REC are expected to increase in next years, contributing to achieve the European decarbonization goals, raising greater challenges in terms of supply management due to the intermittency of renewable generation. Thus, a higher pressure is put on DSM-based BM, which are key to strengthen the system stability, optimize the integration of intermittent renewable resources and create new value streams since demand flexibility may be aggregated and traded in electricity markets [52]. Finally, energy communities can also be created to provide EE and e-mobility integrated services, fulfilling the activity list announced by both directives.

3. Methodology

A three-step empirical-based review approach was implemented to summarize and compile the existing research in ECBM as presented in Fig. 5.

Firstly, a generic research question was outlined: "*how are the different energy community arrangements classified under the business model perspective?*". Then, based on the Osterwalder and Pigneur's BM definition, three additional questions were considered to guide and frame the research: 1) *what is the value proposition of each BM? 2) what services are provided, to whom and at what cost? and 3) what are the main barriers to be overcome?*

Secondly, a systematic literature review procedure was carried out to identify and select a representative set of documents to answer the previous research questions. Within this step, we searched in several databases including: Web of Science (all databases), Scopus, Science Direct, Google Scholar and IEEE Xplore. These databases were chosen due to their comprehensiveness and multidisciplinary nature. The inclusion criteria were defined by focusing the search on the terms 'energy', 'community', 'business models' and 'value proposition' in the articles' title, abstract and keywords. No time span was defined, and the search was not constrained by specific technologies (renewables or fossil-fired), activities performed or energy vectors (electricity and heat). These results were exported to an Excel file containing information on authors, title, date of publication, keywords and abstract. The initial selection was further fine-tuned (Table 1) through a set of exclusion criteria, namely: 1) the search terms should appear more than once throughout the text; 2) documents purely addressing technical, economic or social were excluded since the analysis was aimed at comprehensive approaches encompassing multidisciplinary aspects; and 3) documents dealing with very specific BM were not considered (e.g., designed for a particular situation and not displaying the potential to be replicated in other contexts). Criteria 2 and 3 aim to eliminate documents that misuse concepts such as 'business model' or 'value proposition' to refer to models/configurations but without actually describing the underlying business model or value propositions, as well as to ensure that the selected documents do not refer to very context-dependent situations and not replicable in different contexts. In addition, the research also included reports developed within the scope of energy community projects, as they could bring added value and further understanding of implementation barriers. As a result, the search process selected about 30 documents, including peer-reviewed papers, conference proceedings and technical reports. From these, by searching for keywords as 'members', 'participants', 'investors', 'activities', 'ownership', 'value' and 'barriers' or similar terms throughout the document analysis, information was collected regarding the stakeholders, the activities performed, the possible governance and legal forms, the asset ownership, the perceived implementation barriers and the value created.

Thirdly, the information collected was synthesized and homogenized as different terminology was used to refer to the same issue. This stage allowed to systematize the proposed archetypes, some of which deriving from projects already implemented in real settings, pilots or proof-of-concept projects. Then, each BM archetype was fully described according to the BMC and LC, highlighting their core activities, the market challenges they aim to respond to and the competitive advantage they offer. The energy and payment flows are detailed in customized diagrams and although the physical and technical dimensions related to power quality and reliability issues (created by harmonic producing loads, momentary voltage drops, etc. [70,71]) are not explicitly mentioned, they are assumed to be ensured.

The BM dimensions description follows a specific filling order. First, the 'customers segment' is identified to understand the entities targeted by each BM. Then, the market problems each BM archetype aims to solve are acknowledged, as well as the solutions it offers. The next step aims to outline each BM 'unique value proposition' and then the key activities,

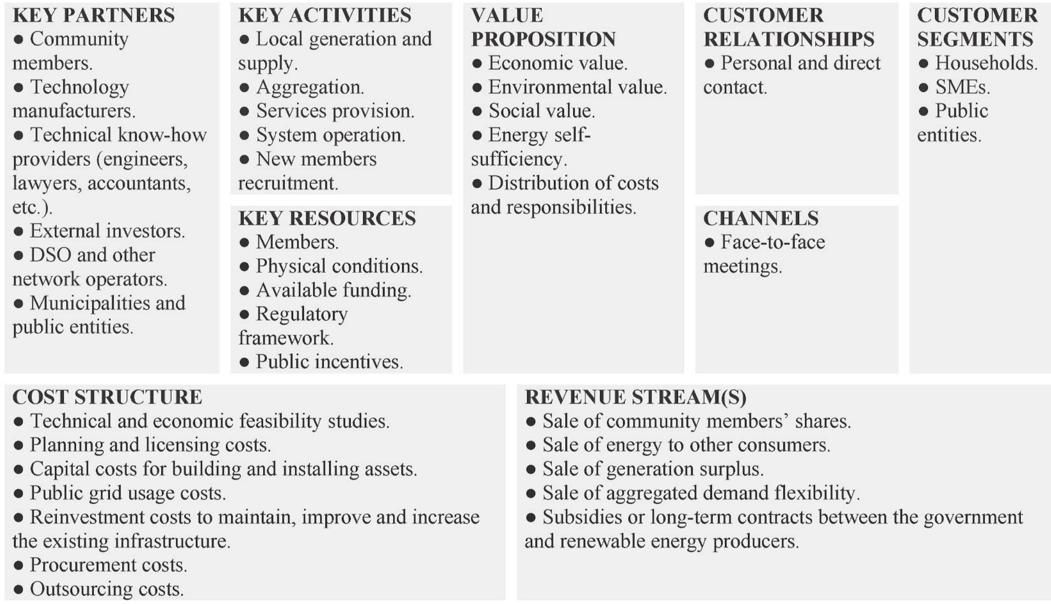

Fig. 4. Energy community BMC.

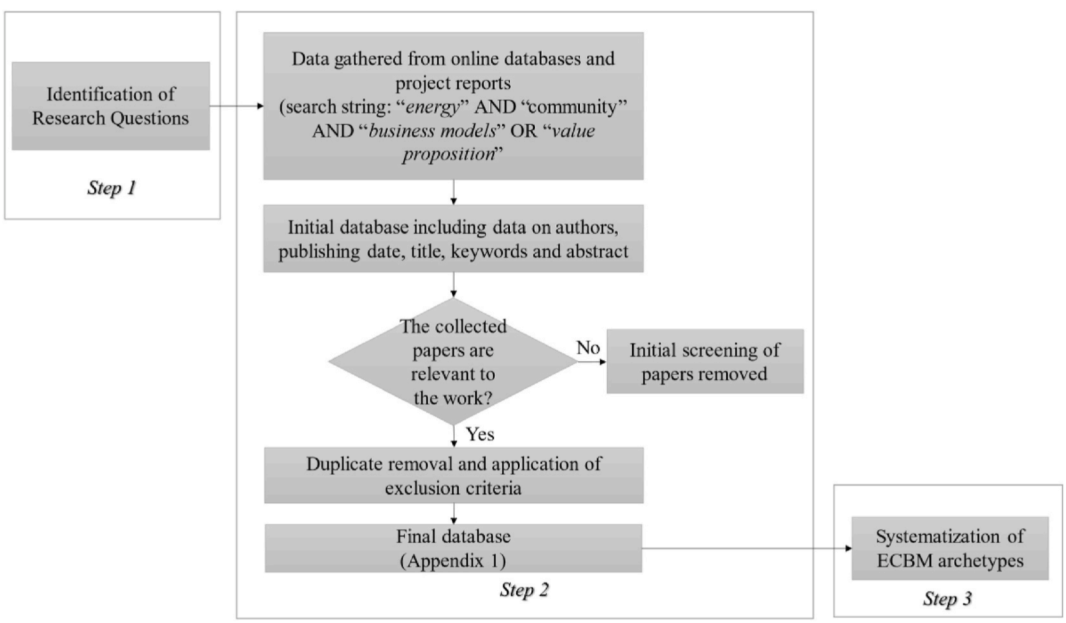

Fig. 5. Energy community BMC.

Table 1
Details of the review procedure.

		Web of Science – All databases	Science Direct	Google Scholar	Scopus	IEEE Xplore	Total
Initial number of results		23	37	27	10	2	99
Removed due to duplication		9	11	7	2	0	29
Removed due to exclusion criteria		13	17	11	4	1	46
Final number of results		1	9	9	4	1	**24**
Documents included	Papers and conference proceedings	[6,13,15,21,28,30,35,46,47,50,52,53,55–57,61,62,64,75–77,83,95,96]					
	Reports	[9,12,14,20,34,65]					

partners and resources required are highlighted. The 'channels' through which products/services reach the customers and the relationships established between ownership structures and community participants are described. The BM 'revenue streams' and 'cost structures' are then investigated and 'key metrics' are proposed to evaluate the BM performance. For each archetype, examples of indicators are proposed. Finally, the BM 'competitive advantage' is discussed.

The description of the ECBM archetypes is further complemented by the analysis of thirty-six projects implemented across Europe, which are listed in Appendix 1. These projects were selected based on their distinctive characteristics and examined considering their legal structure, geographic scope, ownership, activities, actors and expected outcomes. Their inclusion aimed to illustrate real configurations, practical operationalization details, the most common arrangements and the perceived implementation barriers. A broad analysis of these projects stresses the high proportion of community initiatives in countries such as Germany, Denmark, United Kingdom and France and the large number of energy cooperatives.

4. Results and discussion

4.1. Energy community business models archetypes

Eight BM archetypes were identified from the literature and their core dimensions are comprehensively presented in the following sections. Although this list is not extensive due to the high number of possible hybrid models, it gives an overview of the main ECBM, considering the different objectives, ownership rules and actors currently considered.

4.1.1. Energy cooperatives

Energy communities organized as energy cooperatives are by far the most common in Europe [9]. Currently, about 1500 renewable energy cooperatives are members of the European federation of citizen energy cooperatives (REScoop.eu) (more than 800 have been reported in Germany only [12]), serving more than one million European citizens [11]. However, the real number of such initiatives is uncertain and an inventory carried out by REScoop.eu was able to identify more than 2400 renewable energy cooperatives across Europe [72,73].

Energy cooperatives are a classical example of citizen-led initiatives in which end-users join to raise the funding for owning energy generation systems [11,66]. Various organizational forms and financing models may exist but all of them are based on voluntary and open membership rules, democratic control (typically based on the '*one participant one vote*' rule) and the economic participation of members [66]. Energy cooperatives are usually constituted as companies (for profit-making) (Fig. 6). In this case, they can be created as retail cooperatives by shareholders involved in the shared-financing of medium and large-size PV or wind power plants (communities of interest), being able to compete with other market players [34]. They can also be local nonprofit cooperatives, created to supply specific local regions (communities of place) on the basis of self-consumption and sale of surpluses (financial outcomes are reinvested in the community) [11,74]. Energy cooperatives may be involved in the management and operation of regional low-voltage distribution networks, acting as local DSO, which allow them to define billing conditions, incentivize self-consumption through dynamic pricing schemes and exempt cooperative members of paying some use-of-system[4] tariffs [35]. For instance, in countries as Portugal, energy cooperatives may play the role of retailers and low-voltage DSO, having grid concession contracts which allow them to buy energy from other suppliers and resell it to consumers [68]. In turn, in countries as The Netherlands, energy cooperatives can only be involved in local generation and supply, without assuming any specific role in network management [68]. Also, although some cooperatives are created to provide renewable energy to their members at cheaper or market equivalent prices [75], others, acting as retail cooperatives, can charge tariffs above retail competitors, justifying the gap with the remuneration of suppliers (as is the case of the French *Enercoop* initiative presented in Appendix 1) [64]. Additional energy cooperative models are summarized in Appendix 1, projects 1–26.

Energy cooperatives governance is usually in the hands of shareholders (households, SMEs, public entities and other investors), being part of the revenues reinvested in the community (e.g. improvement of infrastructures) and the rest distributed among the shareholders according to the cooperative statutes [9,34]. Thus, cooperative shareholders may be supplied with renewable energy while being financially compensated by their investments through direct payments. Larger energy cooperatives can benefit from collaborating closely with municipalities, which can provide extra sources of technical knowledge and funding. In some cases, the management responsibility is put in the hands of public entities (municipal utility BM), which become responsible for managing the energy cooperative on behalf of customers, while benefiting from cheaper energy for public services (as street lighting) [20,54,76]. Municipal energy cooperatives have been developed in countries as Denmark, Germany, France and Spain, where municipalities play a role in either energy supply and distribution activities (e.g. *Eléctrica de Cádiz*) or in supply only (e.g. *Barcelona Energia*) [68].

4.1.2. Community prosumerism

Energy communities dedicated to prosumerism are typically communities of place created by prosumers, playing the role of decision-makers, investors and customers, who join to benefit from special financing conditions in the acquisition of assets (as bulk purchase), to gain dimension to participate in flexibility markets, to benefit from collective EE initiatives or to participate in LEM [35,77]. For instance, the *Svalin community* in Denmark is a successful case of a community prosumerism BM which aims to maximize participants' savings within a peer-to-peer (P2P) energy trading scheme (prosumerism examples are presented in,Appendix 1 projects 27–29).

Collective or individual generation and storage systems are acquired and long-term PPA are established between community members and energy suppliers, which become responsible for buying the surplus generation and supplying the remaining required power. Community members can also buy and sell all their electricity within the community boundaries (in LEM), exempting them from paying tariff components related with medium and high voltage distribution and transmission networks [78,79]. In turn, if transactions with non-community energy suppliers are established, *use-of-system* tariffs are due. In these arrangements, power and monetary transactions between community participants and external retailers can be intermediated by local grid controllers, which keep record of all the exchanges (Fig. 7).These devices can play a passive role by keeping the record of the transactions (as ledgers), or an active one helping participants to make decisions and interfacing with external players (as choosing better supply offers or facilitating the establishment of smart contracts [80]). By joining in communities, prosumers may aggregate their demand and surpluses, gaining extra power to negotiate better conditions with retailers and last resort traders. This is one of the main benefits of these BM, although they require consensus from all parties, and physical and technological infrastructures capable of supporting and keeping track of energy, money and information transactions for billing purposes.

Potential revenues obtained by selling excess energy can be distributed by prosumers to reimburse their investment or reinvested in the community, to improve social infrastructures and expand installed generation or storage capacities.

4.1.3. Local energy markets

LEM are typically developed by prosumerism-driven communities, which aim to work collaboratively to maximize their self-sufficiency and reducing the amount of power traded with external entities [35,63,81]. In LEM, trading conditions, as pricing, can be directly negotiated between market participants (prosumers and consumers), allowing prosumers to select to whom they sell their energy and consumers to choose the market participant they buy their energy from, at the same time as they know how it is generated [81,82]. In these BM, the revenues from

[4] Use-of-system tariffs are intended to recover the costs incurred by DSO, transmission system operators and other system operators, which are responsible for installing, maintaining and operating the distribution and transmission grids. These tariffs are charged to customers and distributed among the different system operators.

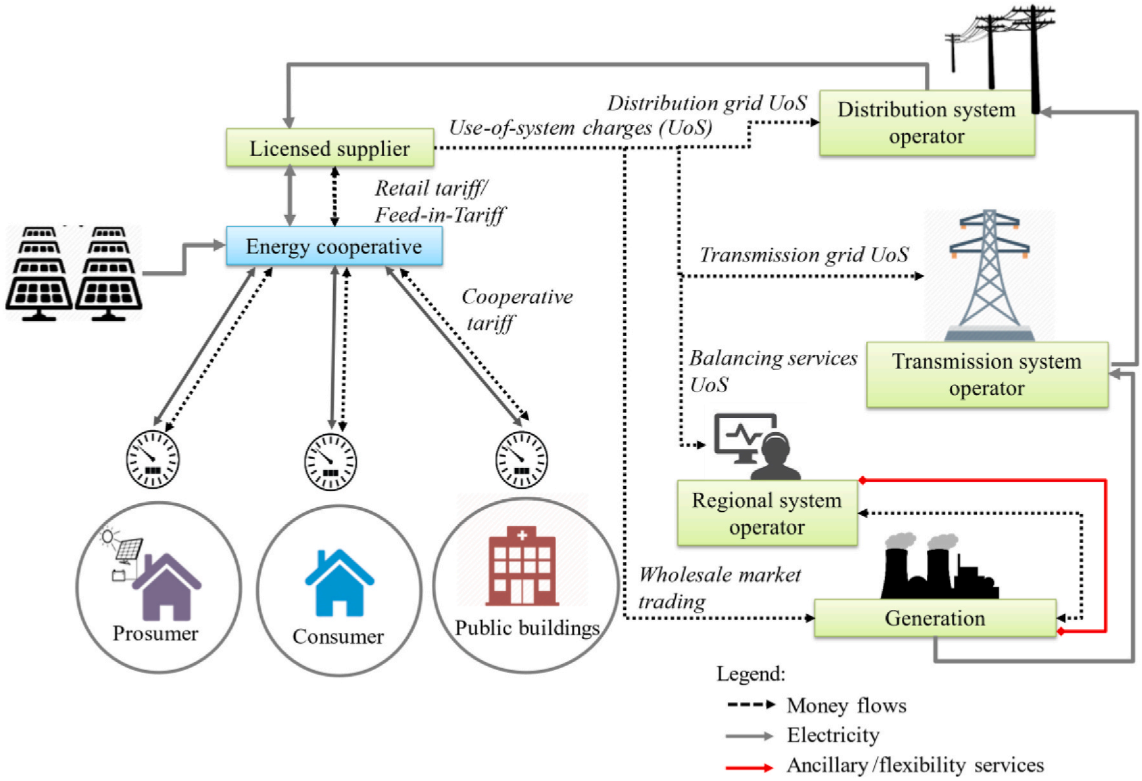

Fig. 6. Energy cooperative BM.

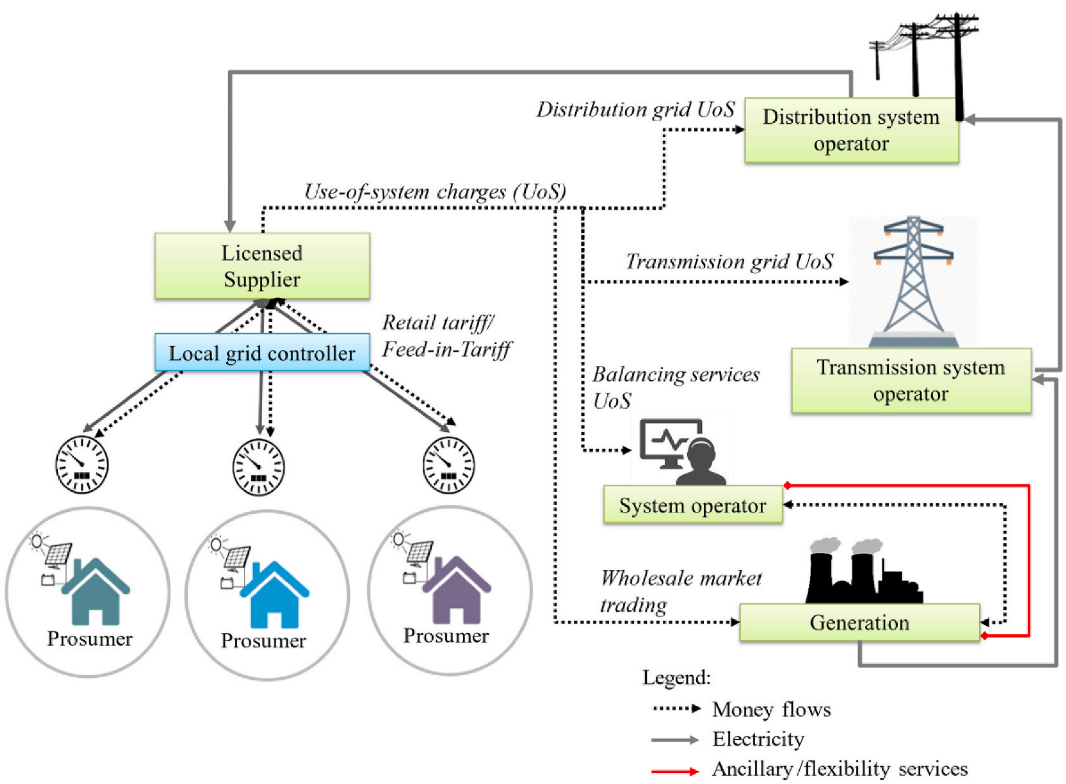

Fig. 7. Community prosumerism BM.

energy sales are typically distributed among prosumers and consumers who benefit from savings due to differences between retail and market tariffs. Market participants consensually manage the trading platforms, while agreements are signed with energy retailers and the DSO to guarantee the supply and trading system reliability.

LEM members (consumers and prosumers playing the role of investors, decision-makers and customers) can be closely located physically (e.g., within the same low-voltage distribution grid), giving rise to place-based LEM. Members can also share common interests but be physically apart, joining virtually to create community virtual power plants [83] or prosumer-community groups [31]). Community virtual power plants are still rare in the EU setting mainly due to regulation limitations. For instance, in Belgium, a community virtual power plant project is facing major difficulties due to the regulatory barrier for P2P transactions [83]. Another project is being implemented in Germany, Austria, Switzerland and Italy, connecting people who consume, generate, store and share energy virtually (the *sonnenCommunity* – project 30 in Appendix 1), by taking advantage of smart storage assets. Both the IEMD and RED-II exempt energy transactions under the same distribution grid from paying the unused upstream distribution and transmission networks [16,17]. Therefore, communities of place may be more attractive to these BM as prosumers may sell their surplus generation within low-voltage energy community boundaries at more advantageous conditions [84].

LEM are established to promote P2P energy exchanges either in a fully decentralized way, allowing community members to freely negotiate with each other [85], or more centrally, through intermediate entities. These entities work as trading facilitators between the market participants, find the best matches and solve community imbalances by negotiating with retailers [69,84]. A hybrid approach between the two previous BM is also possible, which is, for some authors, as [84,86], the most suitable solution for scalability. Despite the attention received in the literature, issues related with the negotiation processes among peers, as well as local energy balance control issues, have prevented the exploitation of full decentralized P2P markets in real settings [87]. In turn, centralized markets have been paid less attention, although they are expected to become more common in the next years [88]. However, due to their configuration, centralized markets are limited to communities of place [69,89,90].

Sophisticated ICT, net-metering infrastructures and software-based trading platforms are required to keep record of all energy, information and money transactions (Fig. 8). The blockchain technology has been identified as a powerful ledger scheme to keep track of the transactions in LEM, although it requires a considerable computational power and energy consumption due to the need to solve security and cryptocurrencies related problems [91].

4.1.4. *Community collective generation*

Collective self-consumption BM are based on shared generation (usually solar PV) and storage systems, which are installed on the rooftop of multi-tenancy buildings or in the vicinity of consumption sites, being the power output shared among several customers (Fig. 9). Due to their characteristics, these BM are constituted as communities of place. Typically, the investment is shared by the dwelling owners (consumers, decision-makers and investors) and sophisticated net-metering and ICT-based infrastructures are required [92]. Also, the distribution of the self-generated energy and potential revenues from the sale of surpluses depends on rules established voluntarily and collaboratively among all project participants [93].

These BM are emerging across Europe. The *Windkraft Simonsfeld* and the *Za Zemiata* are examples of collective generation initiatives being implemented in Austria and Bulgaria, respectively (Appendix 1, projects 31–33). In some countries, these projects are implemented as micro-grids, and surplus sales are not allowed [94]. Thus, the regulatory framework can limit innovation in these BM.

4.1.5. *Third-party-sponsored communities*

The potential of ECBM has been recognized by several entities interested in supporting and investing in the sector [95]. Looking for expanding their customers and services portfolios [55], utilities and technology companies may be willing to provide technical advice and financial support in the form of grant funding, dedicated investment funds, or fully financing energy community projects [95]. When these entities finance such projects, they usually maintain the assets ownership, being responsible for the project governance and investment decisions. In these circumstances, the entities sponsoring the project are the main decision-makers but cooperate closely with local communities to build customized energy supply solutions and community representatives are usually involved in the decision-making processes [55]. The whole financial effort and risks are put on the investors side, which are remunerated through long-term PPA signed with customers. Users benefit from renewable and typically cheaper energy while being engaged in local energy-related programs.

Community virtual power plants [30] can be exploited by companies owning several energy projects. These management models are already in place in some pilot-projects across Germany and the Czech Republic [68]. The so-called 'local pool and sleeve' BM are also starting to

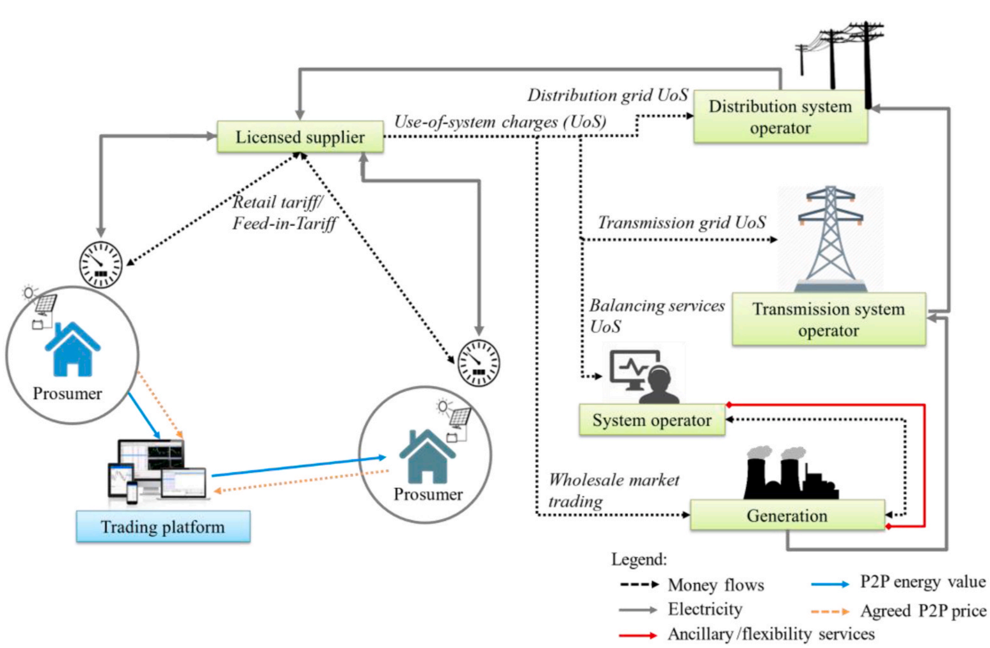

Fig. 8. Community LEM based on P2P trading.

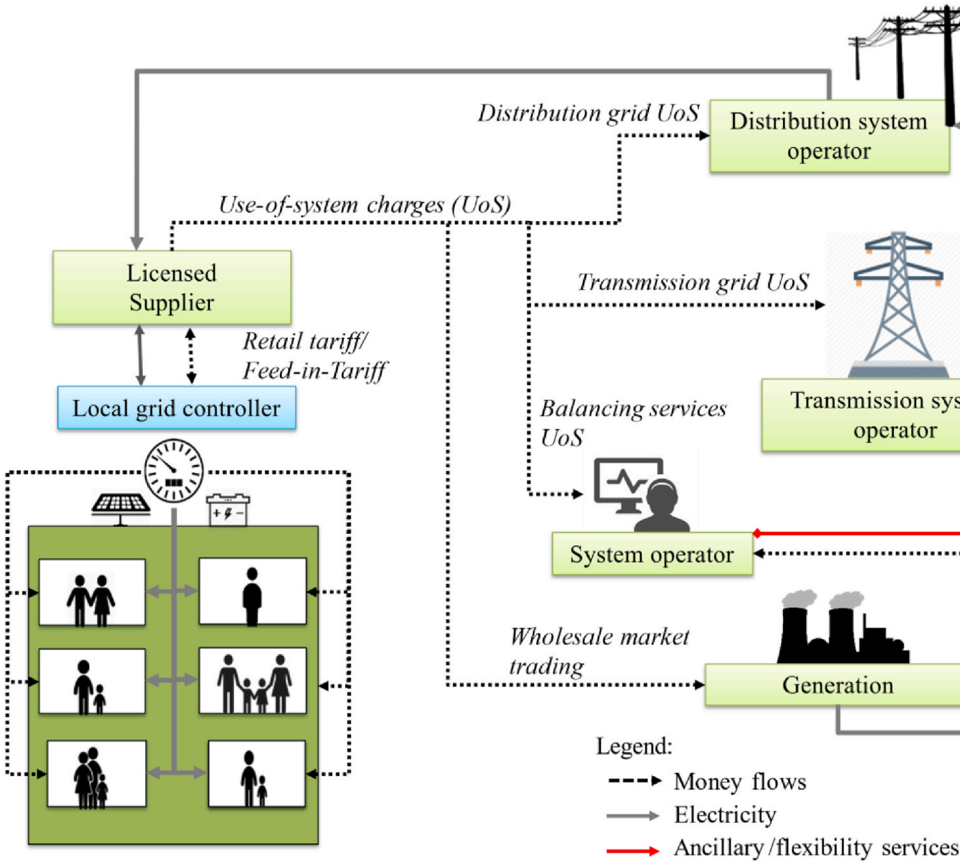

Fig. 9. Collective self-consumption system BM in multi-tenancy buildings.

increase in communities sponsored by utilities, which pool distributed generated resources from a geographical area to supply a specific set of customers without using other wholesale market actors (sleeving) [20]. Fig. 10 displays the described BM general architecture when it is run by a utility.

In turn, non-profit local authorities and social entrepreneurs, aiming to create local economic development [65], to alleviate specific social problems (as poverty and poor housing conditions) and boost social

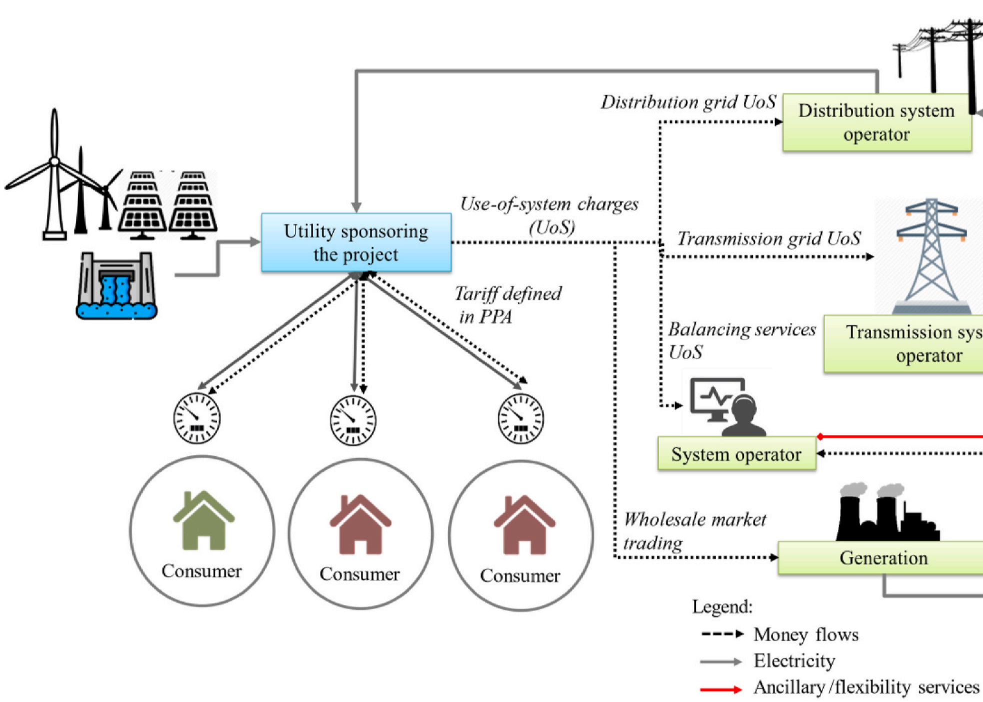

Fig. 10. Utilities-sponsored BM archetype.

change, may also promote energy community projects in specific areas (usually socially disadvantaged) [96,97]. In these models, the social entrepreneurs raise the required funding and keep the infrastructure management close to local consumers, promoting engagement. The profits obtained from the sale of surplus energy are fully reinvested in the community.

4.1.6. *Community flexibility aggregation*

More sophisticated and technology-dependent BM can also be deployed in communities aiming to engage in collective DSM strategies to provide demand flexibility to grid operators through aggregation [98]. Flexibility markets are difficult to access by small consumers, who may face high costs and fail to meet the compulsory volume requirements. In Europe, aggregation BM are usually targeted to industrial and commercial customers as they can provide larger amounts of flexibility [99]. However, energy communities are expected to make residential demand flexibility commercially attractive and European directives strongly encourage aggregation, recognizing the potential of these BM in generating new revenue streams [98]. By pooling the available flexibility provided from multiple members, community aggregators can achieve the volumes required to make offers in balancing, reserve and ancillary markets, thus enabling the participation of small end-users in such markets [99].

Community aggregators may be created to operate at a local level and the flexibility collected is grouped by a larger aggregator. Alternatively, community aggregators can also operate directly at the power system level, provided they are able to meet the required conditions (Fig. 11). Bilateral contracts are signed between community aggregators and customers through which customers commit to deliver fixed amounts of flexibility by changing energy consumption patterns and benefiting from reduced energy bills. Dispatchable and non-dispatchable DSM programs can be implemented to exploit customers' flexibility. In dispatchable programs, customers voluntarily accept that external operators control their appliances during peak periods through direct load control [98]. In non-dispatchable or price-based programs, customers are exposed to dynamic pricing signals to influence their demand profile [98]. Penalties can be charged if the promised amounts are not delivered, strengthening the commitment on the customer side [99]. In these settings, community members have one contract with external energy suppliers to buy/sell the required energy and the surplus generation in a typical prosumerism contract, and a separate one with the aggregator [99]. Sensors, smart meters, HEMS, monitoring apps, etc. are provided by aggregators to help customers delivering the contracted flexibility [50].

Due to the characteristics and activities performed, these communities are generally made up of members who share the same interest in participating in flexibility markets (communities of interest) and can be started by aggregators, who aim to exploit these niches, or by end-users. Although the financial effort is entirely or mostly made by the aggregator, end-users are considered in decision-making moments through the specification of preferences and boundaries expressed in contractual clauses. Regulatory frameworks play a key role in the deployment of these BM as they can constrain the aggregators scope of action. Also, technological and ICT infrastructures are key for the success of aggregation activities.

4.1.7. *Community ESCO*

External companies may establish partnerships with energy communities to jointly create and operate community ESCO aiming to provide EE services (e.g. energy audits, buildings insulation, etc.) and/or renewable energy supply (electricity, heat or both) [100]. Energy communities driven towards energy demand reduction via EE strategies and procuring electricity and heat combined solutions are specially targeted by these BM (Fig. 12) [34,100]. Thus, ESCO BM can be simultaneously defined as communities of place and interest.

ESCO are different from traditional energy consultants or technology suppliers as they can also finance systems and their remuneration generally depends on the energy savings achieved by customers. Several BM variants can be exploited. For instance, the solar-as-a-service BM allows end-users to become prosumers, with community ESCO financing the PV panels and assuming the responsibility for the installation, maintenance and upstream supply [18]. Heat-as-a-service is also commonly exploited in district heating and combined heat and power projects, with ESCO owning the infrastructure and offering energy

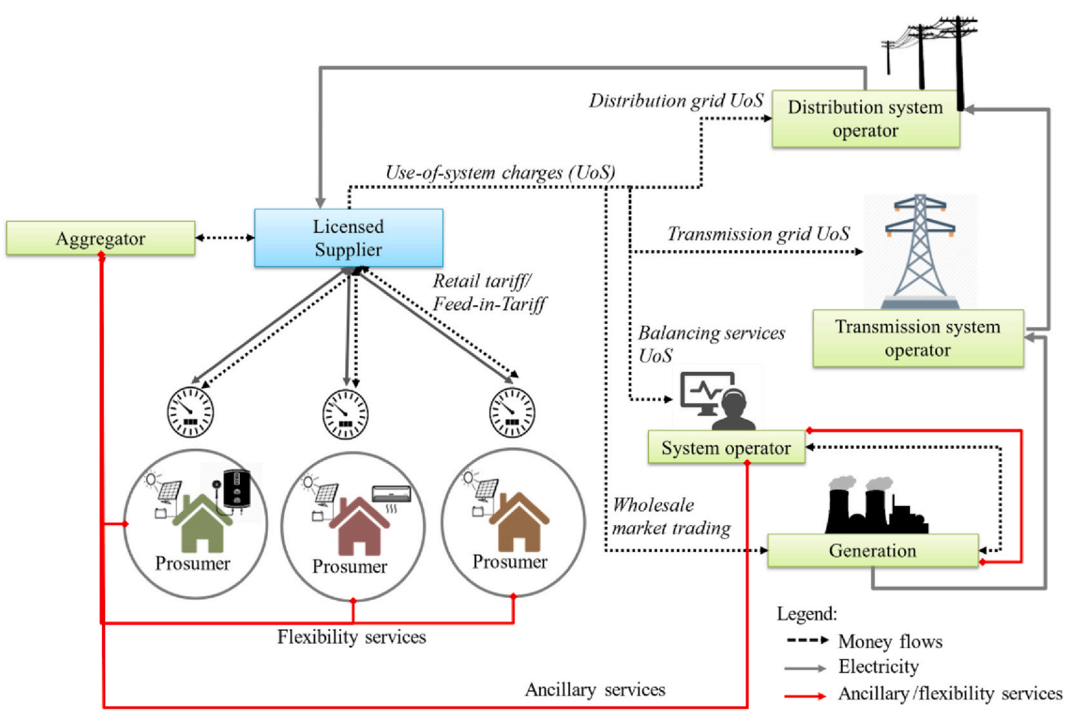

Fig. 11. Community aggregation BM.

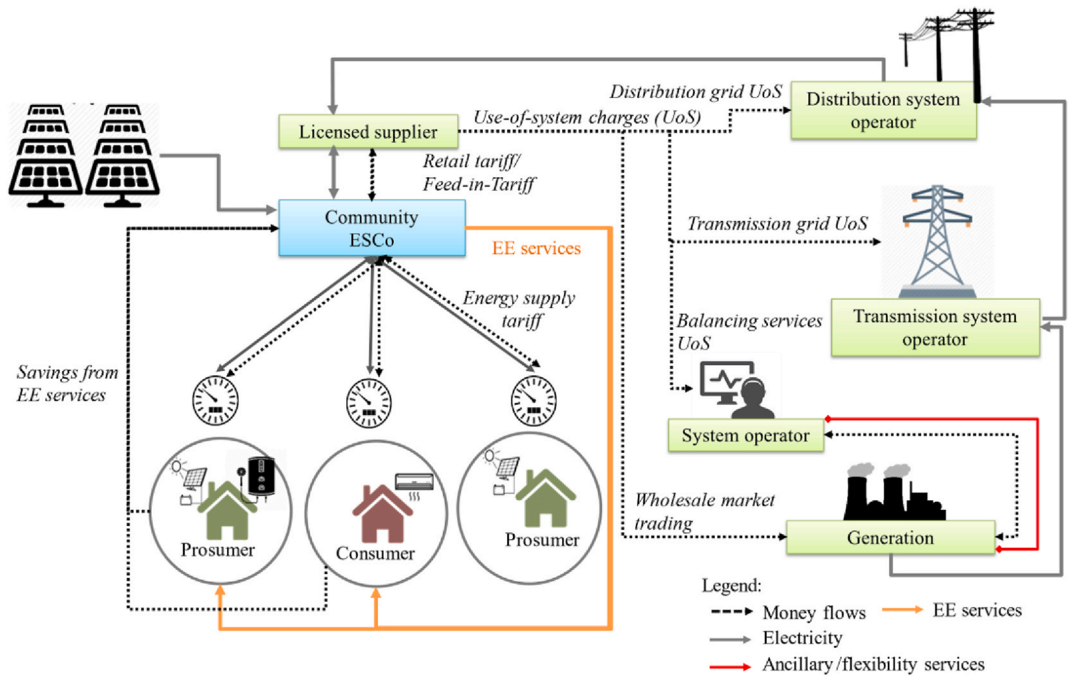

Fig. 12. Community ESCO BM.

performance contracts for internal temperature comfort [18]. In both cases, besides generation systems, community ESCO can also provide energy efficient systems (air conditioners, electric water heaters, etc.) and buildings retrofit solutions. By providing such services, ESCO ensure customers extra energy savings, which, in turn, safeguard ESCO remuneration as these companies are only compensated by the energy savings achieved. Two main ESCO remuneration schemes are possible: guaranteed savings, if ESCO promise to deliver certain levels of energy savings, or shared savings, if the savings attained are split during a given period in accordance with a pre-defined contract between customers and ESCO [101]. Customer savings can be shared between ESCO and customers in different ways and used to reimburse ESCO of their investments or for local reinvestment. In these BM, investing companies hold the assets, structures and the decision power. However, as the projects are customized and dependent on local conditions, members of the community are deeply involved in the decision-making processes. Depending on the extension of the investment needed to provide contracted services, economic barriers can halt these BM.

ESCO are more common in Member-States exploring combined power and heat solutions [100]. Therefore, it is expected that community ESCO BM will also have greater relevance in communities exploiting combined solutions [100]. The *Chase Community Solar* project, in the UK, is an example of a community ESCO (project 34 in Appendix 1).

4.1.8. E-mobility cooperatives

CEC and REC encourage EV as mobility solutions, providing fossil-fueled free transportation services, and as extra sources of flexibility [16,17]. Thus, e-mobility based BM may develop clean mobility solutions, while alternative value streams are exploited. E-mobility cooperatives are created by engaging shareholders (households, SMEs, public entities, social and technical entrepreneurs, etc.) to provide community public transportation, car-sharing or car-pooling services (projects 35 and 36 in Appendix 1). These cooperatives can also exploit their assets (electric cars, buses, motorbikes, etc.) as flexibility resources [35,52]. Batteries can be used as storage resources, exploiting vehicle-to-grid and grid-to-vehicle modes to reduce energy bills by procuring energy during off-peak periods and providing flexibility services, which can be pooled by aggregators to deliver ancillary services to the grid [35]. Additionally, if these cooperatives are also involved in power generation, battery storage helps to maximize local self-consumption and self-sufficiency. In these BM, community participants may be involved (through partnerships or not) as shareholders, decision-makers and mobility customers.

In energy communities with high shares of EV (communities of place), smart charging schemes can be designed to schedule load operation to off-peak periods or when local energy generation is available, thus optimizing the utilization of local resources and flattening demand peaks [35]. Hybrid BM, exploiting combined mobility and flexibility solutions are also possible [35]. One example is presented in Fig. 13, which illustrates how community mobility service providers can be created to offer e-mobility services with energy generated by community members [35]. These mobility providers own EV and/or electric buses to deliver car-sharing or public passenger transportation services, for profit-making, being powered by energy resources delivered by community prosumers. In these settings, instead of selling their surplus generation to an energy supplier, prosumers would make it available, upon payment or reduced service prices, to e-mobility services providers. As these BM are developed for profit-making, fees are charged for the services delivered [35]. Usually, partnerships between energy communities, DSO, energy suppliers and EV technology providers may be required.

These models are highly technological and require reinforced physical structures to handle the power demanding charging processes of e-mobility assets. In addition, regulatory barriers, due to vehicle-to-grid and grid-to-vehicle transaction, and economic barriers triggered by the large volume of investment may hinder the development of these BM.

4.2. The BMC and LC perspectives

In the next sections, the proposed BM archetypes are described according to the BMC and LC core dimensions.

4.2.1. Customers segment

In general, the ‘customers segment’, as defined by the IEMD and RED-II, may include households, SMEs and public institutions. Some

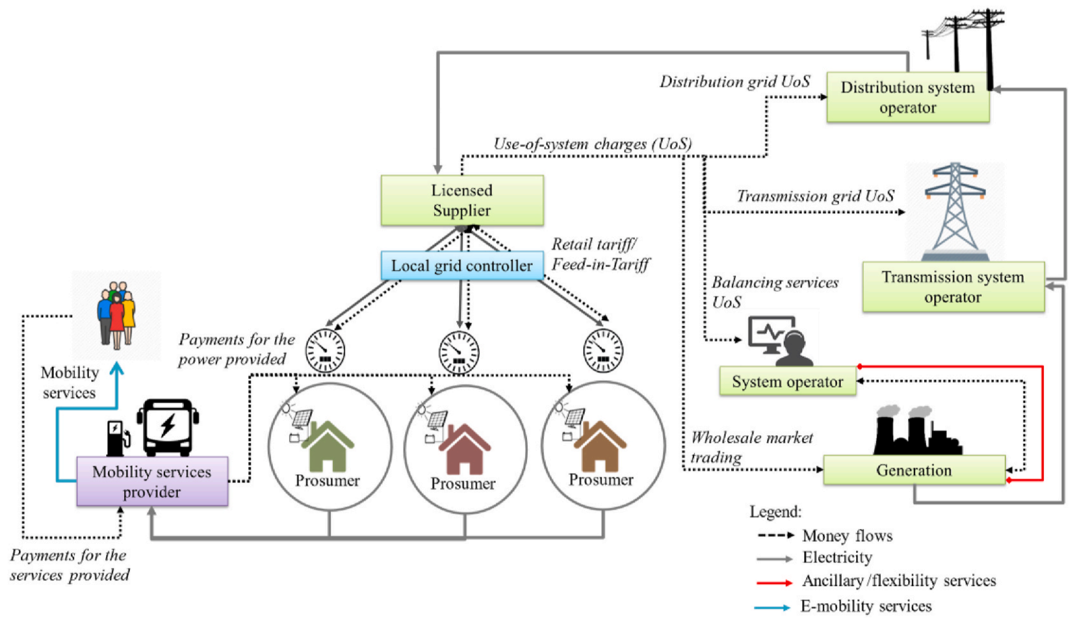

Fig. 13. E-mobility cooperative BM.

ECBM require the 'customers segment' to have the financial capacity and the available space conditions to become prosumers (community prosumerism and LEM), while others promote the participation of public institutions (energy cooperatives) or the inclusion of low-income consumers (third-party-sponsored ECBM). Multi-tenancy buildings, where space is constrained, are the focus of collective generation BM, whereas end-users living in smart homes or owning appliances deemed for demand management and willing to accept DSM actions are targeted by community aggregation BM. Communities developing EE or e-mobility services are targeted for customers aiming energy-efficient integrated solutions.

4.2.2. Market challenges and proposed solutions

The need to solve energy supply issues and the willingness of consumers to participate in local generation, self-consumption and trading activities, underpins the creation of most energy communities. Several BM may be settled to provide cheaper and reliable local energy supply (energy cooperatives, community prosumerism, collective community generation, LEM and third-party-sponsored initiatives), allowing to minimize the dependence on external supply parties by deploying energy chains involving generation, supply and trading. In these settings, the high initial investment, the lack of space for implementing generation and/or storage assets and the reliance on external entities to ensure the distribution of the locally generated energy may hinder their deployment. The high up-front investment barrier is overcome through shared investments, partnerships with public entities and utilities which become responsible for financing community projects, while long-term PPA are signed with customers to warrant investors payments. The lack of space for generation facilities is solved by sharing collective generation and storage assets or building offsite power plants. The reliance on distribution entities facilitates the emergence of communities responsible for managing both generation and distribution facilities, playing the role of energy suppliers and local DSO.

The lack of integrated solutions to provide EE and e-mobility services fosters the emergence of ECBM committed to delivering such services. Finally, the need to grasp the necessary volumes for participation in flexibility markets boosts the emergence of community aggregation models. The aggregation of community members' flexibility (or aggregation of multiple communities' flexibility) solves the problem identified in communities aiming to participate in energy markets, whereas the creation of local ESCO and e-mobility services providers allows communities striving for implementing integrated energy-efficient solutions. Most of these BM require sophisticated ICT infrastructures to guarantee information exchange in real time.

4.2.3. Value proposition

Overall, the 'unique value proposition' of ECBM is the opportunity to be involved in the energy generation process and the sharing of the up-front costs, as the economic barrier may hinder the participation of end-users in these settings. Communities mostly engaged in prosumerism activities publicize energy self-sufficiency and the access to renewable energy to end-users aiming to reduce their energy bills by self-consuming and selling their surplus generation as their main 'value propositions'. Also, providing the access to renewable energy and collective behavioral change in communities without the required physical and economic conditions, which would never have the means to benefit from such services (through third-party-sponsored or collective generation BM), are the 'unique value propositions' offered by such models. In turn, the possibility to participate in energy markets through aggregation and the creation of customized EE and e-mobility services, while exploiting alternative value streams (as the extra flexibility provided by EV storage) are the 'unique value propositions' offered by BM deployed in communities aiming to exploit DSM strategies and provide energy services. The economic driver may be understood as a relevant 'value proposition' of some ECBM as energy cooperatives.

4.2.4. Key activities, partners and resources

Most of these BM 'key activities' include energy generation (onsite and offsite), consumption, trading, management, distribution and supply, as announced in the European directives. Additionally, all the backstage activities (as daily operation, repair and maintenance, marketing, recruitment of new members, etc.) must be considered since they are key in supporting the projects over time. Specific BM may request customized activities. For instance, the community aggregation BM 'key activities' are based on the monitoring, controlling and pooling of the demand flexibility provided by customers, interfacing with system operators to trade the aggregated resources and establishing penalties for non-compliance.

To perform such activities, 'key resources' are required, namely: 1) the members willing to participate and the investors willing to finance these projects; 2) the physical space to install generation and storage assets (onsite or offsite) as well as all the required technical infrastructures (ICT, net metering, distribution networks, etc.); 3) the regulatory framework, shaping the role of local DSO, aggregators, and all the potential entities involved in ECBM; 4) the long-term financial means to support project implementation over their lifetime (e.g. government incentives spread over time to encourage and maintain the interest of shareholders and participants); and 5) demand flexible loads to exploit demand sensitive BM. 'Key partnerships' are established between energy communities and: network operators, since distribution networks are used; retailers and last resort traders, which ensure communities power deficit selling and surplus generation buying; technology providers, which may offer relevant technical assistance; social entrepreneurs, local entities, utilities or other partners financing projects; and system operators, if demand flexibility is exploited for commercial purposes.

4.2.5. Channels and customer relationships

Overall, in energy communities, direct and close relationships are established between the different entities through direct (face-to-face) and indirect (e.g. digital, written) communication channels, including meetings, client support platforms, websites, etc. In more technology-based BM, as community aggregation and community virtual power plants, the relationships with customers is mostly indirect and supported by automated devices. Also, these relationships are commonly established over a long period of time consistent with the lifetime of the project to ensure its stability and financial continuity as well as the interest of the stakeholders. For this purpose, physical infrastructures (generation and storage assets, distribution networks, smart meters, HEMS, etc.), automated devices and key partnerships (DSO, energy suppliers, etc.) are required.

4.2.6. Costs structure and revenue streams

The 'cost structure' and 'revenue streams' of the ECBM archetypes discussed are quite similar. All the BM involve fixed costs, incurred over the project lifetime (as energy procurement costs, if the project cannot guarantee the total supply of energy to its members and acquires energy from third parties, technology and land acquisition costs, rents, interest expenses, assets depreciation, etc.), and variable costs (as wages and other monthly operating costs). Communities using public distribution or transportation structures must also include the payment of use-of-system tariffs. These payments must be considered whenever the community does not control its local distribution network. In turn, the costs of building new community distribution networks must be included if they are required to ensure the contracted services (e.g. heat distribution networks for community ESCO BM). Also, costs related with technical-economic feasibility studies must be considered in projects 'cost structures' as they raise investors' attention. The continuous payments from members or external customers are key to financially support these projects and keep investors and shareholders' interest. The revenue streams include transaction-based revenues due to the selling of energy, EE and e-mobility services and recurring revenues due to long-term contracts. Incentives and subsidies provided by governments to boost renewable-based projects may also be comprised. The selling of ownership shares, surplus energy to other community members, to external retailers or last resort traders, and balancing, reserve and ancillary services to system operators must also be acknowledged as revenue sources.

4.2.7. Key metrics

'Key metrics' to assess BM performance may include a wide range of indicators as the community member savings and the number of community members served by the services (EE, e-mobility, energy supply, etc.) provided by ECBM. In communities driven towards local generation, self-consumption and trading, key indicators can help to understand how systems are performing regarding self-consumption and dependence from external supplying entities, allowing to understand how improvement strategies can be designed to optimize the use of local resources. Therefore, indicators such as the share of community demand supplied by local resources can help to assess the success of these BM. In communities owning and managing distribution networks, key indicators should provide a clear view of possible network issues (as congestion points), whereas communities aiming to manage their demand flexibility should adopt key indicators that inform about the potential of demand flexibility, facilitating the work of aggregators. Consequently, indicators as the community demand flexibility traded in energy markets could reveal how such BM are performing.

4.2.8. Competitive advantage

These BM are flexible and allow members to join or leave at any time, transferring or selling their assets and obligations to others. This feature is not possible or easily implementable in classical BM. Additionally, the social value created in any of these BM is not reproducible in other contexts. The energy autonomy, the increasing resiliency of communities capable of providing differentiated energy services and creating commercial value for residential demand flexibility are the most relevant competitive advantages of ECBM.

Fig. 14 synthesizes and compares the different dimensions of LC and BMC mentioned above, grouping BM according to their main objectives.

4.3. Discussion on the main benefits, barriers and policy implications

All the identified ECBM archetypes generate benefits at different levels [28]. Energy communities are expected to offer economic benefits for the participants and shareholders, whether or not the projects are explicitly developed with a commercial purpose. For example, the Belgian *Ecopower* cooperative (project 3 in Appendix 1) allows shareholders to receive a maximum of 6% of its profits on an annual basis. Along with the economic outcomes, the collective behavior change, the environmental awareness and the community cohesiveness are also transversally promoted by all the BM. When developed by local entities, ECBM promote local job creation, support transformation processes and technological innovation. Energy communities can also create relevant social transformation in marginalized communities which are often neglected in energy transitions due to funding, knowledge and interest limitations. By means of social entrepreneurs or other public and private entities, energy communities can promote awareness and engagement in local communities, with significant repercussions in combating social vulnerability and energy poverty. Thus, the financial barrier for these consumers must be overcome by an enabling framework, as required by the recast of the RED-II, and public funding programs, otherwise the welfare dilemma will prevent socially deprived consumers to benefit from energy community advantages.

Different barriers can delay and prevent the expansion of ECBM [28]. First, financial and profitability barriers related to the required high initial investment, lack of financial resources during the project lifetime and long payback periods can curb the investors' interest. These barriers can be overcome by designing effective financing schemes and facilitating access to credit sources for projects that prove to be technically and economically viable. In addition, inflexible market structures and uncertain feed-in-tariff levels can create hesitation in investors. Second, end-users' acceptance barriers may hinder the deployment of ECBM since people may not recognize the benefits offered by participating in such projects and, therefore, refuse them. The dependency on volunteers to initiate and develop community initiatives, the progressive lack of interest over projects lifetime, the skepticism about renewables reliability and the "not in my back yard" phenomenon (for instance, some cases of local communities contesting solar developments were reported [102]) can compromise the success of these projects. Thus, information and awareness campaigns should be promoted so that end-users realize the advantages of investing and/or participating in collective energy schemes. Third, technological and regulatory barriers may hinder the implementation of ECBM. Currently, the technological barriers are mainly related to the need of deploying and reinforcing the

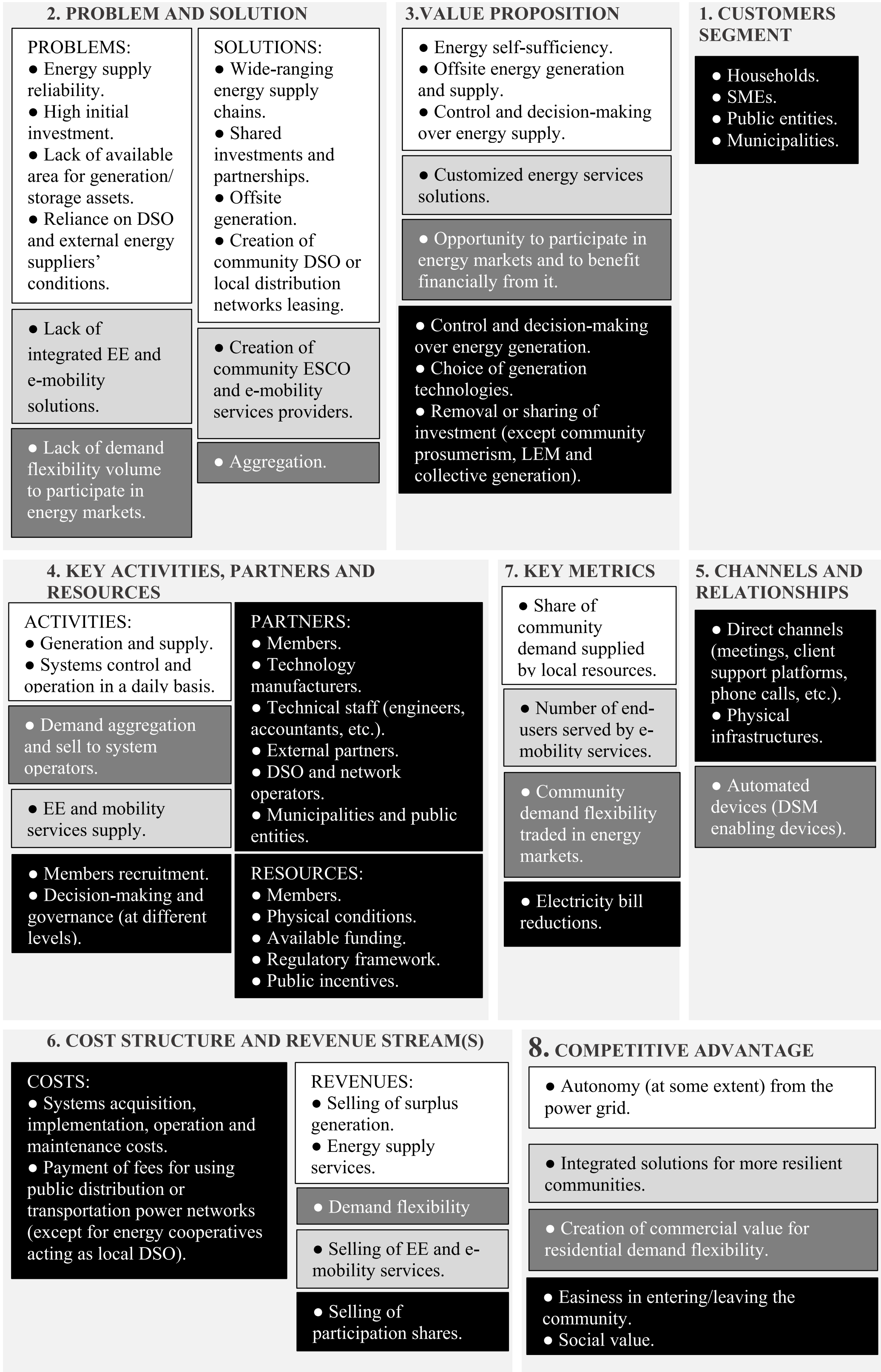

Fig. 14. Comparative analysis of ECBM combining the BMC and LC frames. Color meaning: white text boxes: communities involved in energy generation, self-consumption and supply (energy cooperatives, community prosumerism, collective generation and third-party-sponsored BM); dark gray: communities aiming to manage demand (community flexibility aggregation); light gray: communities providing EE and e-mobility services (community ESCO and e-mobility cooperatives); black: all archetypes.

communications and smart metering infrastructures, which can be overcome with the investment of technology companies and governments. For instance, despite the blockchain technology is identified as a revolutionary technology for the full and safe implementation of P2P energy trading models, the computing and energy consumption issues associated with these platforms are recognized as a brake on its rollout [91]. In turn, regulatory barriers, may be harder to overcome. Most of the existing projects date back several years, which means that many of them do not comply with the rules formulated by the current European directives, currently being transposed into national laws. Thus, flexible transition frameworks must be created to allow the existing projects to continue to operate, providing them with the necessary support to adjust their operation to the new requirements, at the same time as new projects emerge. Also, in order to protect less flexible market structures, regulatory frameworks in some countries are currently impeding the development of more innovative BM. Take the case of the virtual community plant project started in Loenen, The Netherlands, which faced serious difficulties, since point-to-point trading is not yet allowed [83]. Innovation in community collective generation BM has also been compromised by the existing regulatory frameworks. For instance, the French legal framework for collective generation in multi-tenancy buildings allows self-consumption within the building and surplus trading between buildings within a 2 km geographical perimeter [103]. However, in Sweden, the self-generated resources in a multi-tenancy building can only be consumed within the building and surplus injection into the grid is not allowed [104]. By allowing surplus trading within buildings, the French regulatory framework allows the deployment of more innovative BM, as P2P trading, while the restrictive Swedish regulations promote the business-as-usual of collective self-consumption projects. Additionally, community projects will affect the daily operation and the BM of traditional power systems players in several ways. On the one hand, communities can offer energy and flexibility to the grid, increasing the efficiency of general operations and reducing the need for new network investments. Communities can also decrease network congestion issues at the same time as losses in distribution and transmission are reduced. The aggregation of community members generation and demand can also help the system operators to balance supply and demand more effectively, since DSM strategies can be designed for this purpose. Likewise, the balancing services offered by distributed community generation can be used to improve the system reliability and minimize the effects of power outages. Despite the benefits, energy communities may be responsible for revenue losses of key market players, cause disturbances in power grids (as instability in voltage profiles) or give rise to imbalances in tariffs schemes (as regular non-community-members may have to support higher costs for network tariff components). Therefore, policymakers and regulators must be able to design fair policies and pricing mechanisms to ensure energy communities are effectively charged for the imbalances caused in the system while end-users not adhering to community projects are not burdened with the system extra costs. Effective incentive policies and flexible regulatory frameworks, allowing to pursuit different BM, can help to overcome some of the identified implementation barriers and attract private funding.

5. Conclusions

This paper presented a comprehensive literature review on ECBM considering the specifications introduced by the *Clean Energy for all Europeans* legislative package. Eight ECBM archetypes were proposed and analyzed through the BMC and LC lens to identify the market challenges each archetype aims to answer, as well as the unique value proposition offered. Although not extensive, the proposed set of archetypes covers a wide range of possible BM in energy community settings, addressing the current and prospective regulatory and technological frameworks.

Several trends emerged from the present work. First, the majority of the ECBM identified are involved in self-consumption and surplus generation trading, which is explained by the long-lasting tradition of energy cooperatives in Northern Europe countries. These BM aim to engage citizens in local energy generation to achieve some autonomy from the power grid and profit from the sale of surplus energy. Second, the initial shared investment and the provision of the complete value chain including generation, distribution and supply seem to be the main reasons explaining why energy cooperatives are, by far, the most widely exploited collective initiatives. Third, as most community projects are focused on renewable generation, REC are the most prevalent type of energy communities implemented across Europe. Finally, most of the existing projects are financially supported by small local investors (customer-side BM), who are simultaneously involved as asset owners, investors and consumers, whereas third-party investment is mostly used to create value in low-income settings. Additionally, differentiated BM are starting to emerge to allow communities to control their distribution network, optimally manage the resources generated locally, develop local energy markets and provide integrated EE and e-mobility services, lining up towards the CEC definition introduced by the IEMD. Indeed, by not restricting the type of technologies, opening the scope for more activities to be carried out, and allowing communities to own and control their internal distribution network, the IEMD establishes an especially attractive environment for novel BM to emerge. However, due to the IEMD recency, the higher dependence on ICT, as well as the need for new market players operating as intermediaries between customers, network operators and the market, these BM are still in their early development stages from the business perspective.

The present work aimed to shape the discussion on the most promising ECBM at the light of the current regulatory and technological frameworks. It presents models that are still in the pilot or development phase, the results of which may uncover barriers that are not yet fully known. Thus, future research in ECBM should continue to follow closely the evolution of the regulatory framework, simultaneously conveying further information for this process, and develop novel methodologies required by the implementation challenges in real contexts.

Declaration of competing interest

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

Acknowledgements

This work was partially supported by grant SFRH/BD/143530/2019 and by project grants UIDB/00308/2020, SUSPENSE (CENTRO-01–0145-FEDER-000006) and MAnAGER (POCI-01-0145-FEDER-028040) through the European Social Fund, European Regional Development Fund and the COMPETE 2020 Programs, FCT-Portuguese Foundation for Science and Technology, and the Energy for Sustainability Initiative of the University of Coimbra.

Appendix 1. Energy community projects

	Project and country	BM archetype	Key activities	Motivations, governance, ownership and operation	Link
1	*Windkraft Simonsfeld* (Austria)	Energy cooperative	Feasibility studies, project development, financing, choice of equipment, operational management, generation and sale of electricity.	This community of interest was started in 1995 engaging 107 local citizens to produce renewable and collectively owned energy. Currently, the project turned into a joint stock company with more than 1600 shareholders, 68 wind power stations in Austria (with a total power of 136 MW) and 2 in Bulgaria. The cooperative is governed by an administration/management board, assisted by a vast technical team. The shareholders are involved through shares and bonds and are reimbursed through the proportional distribution of financial outcomes. Additional foreign capital is raised through the institutionalized capital market.	https://www.wksimonsfeld.at/
2	*Green Energy Cooperative* (Croatia)	Energy cooperative	Planning, development, management and financing of renewable energy assets and EE projects.	This cooperative was founded by employees of local companies and organizations working in the field of energy and environmental protection, counting currently with 22 members. It is involved in the project management and financing (through financial institutions, alternative financial mechanisms such as crowdfunding, ESCO service, co-financing through funds) of initiatives related with sustainable tourism development, agriculture, commercial and public institutions.	http://www.zez.coop/
3	*Ecopower* (Belgium)	Energy cooperative	Feasibility studies, project development, financing, operational management, generation and sale of renewable energy.	It was founded in 1992 aiming to invest in renewable energy, to supply 100% renewable electricity to their cooperative members, and to promote a rational use of energy. Currently, it has nearly 50,000 members and more than 40,000 customers. Shareholders can buy as many shares as they want, with a limit of 50 shares per person. A single share costs 250 euro and is fixed for a period of 6 years to avoid fluctuations in capital. Every shareholder has one vote in the general assembly. The financial cooperative surplus is used to finance less profitable projects.	https://www.rescoop-mecise.eu/aboutmecise/ecopower
4	*BeauVent* (Belgium)	Energy cooperative	Feasibility studies, project development, financing, operational management, generation and sale of renewable energy.	It was created in 2000 by some households of Westhoek sharing the vision of save energy without sacrificing comfort. Currently, the cooperative is involved in renewable electricity and heat generation and supply. The cooperative also provides EE and third-party financing services. Currently, it has more than 5000 shareholders and collects funds to invest in wind energy, solar panels, biomass and energy-efficient applications such as combined heat and power systems. The shareholder becomes a co-owner of the facilities, can buy electricity from the cooperative and receives an annual dividend (max. 6%). Each share costs 250 EUR, the shareholders' liability is limited to the amount of their contribution and everyone is entitled to vote at the General Assembly, regardless of the number of shares.	https://www.beauvent.be
5	*Courant d'Air* (Belgium)	Energy cooperative	Feasibility studies, project development, financing, operational management, generation and sale of renewable energy.	It started its activities in 2009 and it presently includes more than 2000 members. The cooperative is involved in renewable electricity generation (wind and solar), EE (collective LED lighting, auditing and monitoring), electro-mobility (car sharing) and information awareness activities. The cooperative is open to participation through shareholding. Each share costs 250 EUR and is limited to 3 shares per person. The investment has a duration of at least 5 years and exit is subject to approval by the Board of Directors. Shareholders received annual dividends (max. 6%). Members' money is used to finance renewable energy production tools and projects listed in the bylaws and at the general meeting, everyone votes for the cooperative's important choices.	https://www.courantdair.be/wp/notre-cooperative/
6	*Hvide Sande community* (Denmark)	Energy cooperative	Feasibility studies, project development, financing, operational management, generation and sale of renewable energy.	Since 2010, the community-run wind farm has operated in Hvide Sande, a Danish community on the western coast. The project includes three wind turbines community owned and operated, with around 400 shareholders living in the surrounding area. The expected revenues are invested in the modernization of the local harbor, highly relevant to the local development. The community controlling the wind turbines is founded by several local entities, industries and utilities. 80% of the wind farm is hold by the community Foundation and the remaining by the partner Hvide Sande Nordhavn Mollelaug.	https://hvidesandehavn.dk/en/offshore/wind-farms
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	Project and country	BM archetype	Key activities	Motivations, governance, ownership and operation	Link
	Middelgrunden Wind Cooperative (Denmark)	Energy cooperative	Generation of electricity through the establishment and management of wind turbines on Middelgrunden shoal.	This is a private partnership formed in 1997, with the aim to produce electricity through the establishment and management of 20 wind turbines on Middelgrunden shore. The cooperative is established as a partnership formed by the Working Group for wind turbines at Middelgrunden. Each share corresponds to 1/40,500 of the partnership, which has joint liability. The risks of joint responsibility are minimized by the fact that the cooperative is not being able to contract debt in the partnership.	https://www.middelgrunden.dk/middelgrunden/?q=en/node/35
8	*Marstal District Heating* (Denmark)	Energy cooperative	District heating activities (generation, distribution and supply) based on renewables (solar heat collectors, wood chips, heat pumps, bio-oil and combined heat and power).	Created in 1962 and currently with 1600 members, this is a non-profit cooperative, meaning that all the potential profits return to shareholders as lower energy process. The cooperative board, which is elected annually by the cooperative members, most of them inhabitants of Marstal, manages the daily activities. The general assembly is responsible for decisions, and shareholders are recruited when buying a house in Marstal that is connected to the network. The inhabitants of Marstal financed the original district heating network and since then the cooperative financed subsequent operations by applying to available subsidies and funding programs.	https://www.solarmarstal.dk/profil/om-os/
9	*SAS Ségala Agriculture et Energie Solaire* (France)	Energy cooperative	Generation of renewable electricity through PV technologies for self-consumption and selling.	Created in 2008, the cooperative includes about 180 members. Generation systems are installed in the roofs of farm buildings and the goal is to guarantee an extra and regular income for farmers and to reinvest profits in local assets. The cooperative is financed by shared investment tool existing in France – the Shared Energy - fully dedicated to the financing of renewable energy production and energy management projects which are controlled by groups of citizens. This mechanism advertise profitability targets of 4% gross per year for an investment period of at least 10 years and each share is sold at 100 EUR.	https://energie-partagee.org/projets/segala-agriculture-energie-solaire/
10	*Enercoop* (France)	Energy cooperative	Generation, procurement and supply renewable electricity (solar, wind, hydro, biogas)	Created in 2005 and currently with about 70,000 members, the Enercoop plays the role of a 100% renewable energy supplier by generating and procuring electricity directly from renewable energy producers. Currently, it operates 100 hydro power plants, 25 windfarms, 104 solar projects and 3 biomass generators. Enercoop has a multi-stakeholder governance model (including consumers, producers, partners) in which each shareholder have a day in decisions under the 'one person one vote' rule. Potential profits are reinvested in new projects and financing is collected through bank loans, citizens financing and partnerships.	https://www.enercoop.fr/
11	*Bégawatts project* (France)	Energy cooperative	Renewable energy generation and sell into the power grid (sell to a retailer).	This cooperative belongs to the local non-profit organization "Éoliennes en Pays de Vilaine" which relied on the investment of around 1000 local citizens to install four wind turbines able to supply enough electricity to power 8000 households. The cooperative was fully built and managed by citizens who have struggled to solve different sorts of problems ranging from money raising, since banks were initially unwilling to provide loans, to legal, regulatory and technical issues. The project was initially funded by 1000 private investors, the Energie Partagée investment fund, local communities and banks. It is mostly operated by volunteers helped by technical staff. The electricity generated is sold under a 15-year contract with a guaranteed rate adjusted for inflation and revenues are used to pay bank loans. Shareholders are supplied by utility companies and participate in the project to be involved in renewable power and to have returns on their investment.	https://energyindem and.com/2018/06/23/a-citizens-project-in-france-called-begawatts/
12	*Energy Cooperative of Karditsa* (Greece)	Energy cooperative	Biomass related activities, resources management, energy generation and supply.	The cooperative was established in 2010 with 350 members to exploit the local biomass existing in the area. Agricultural, forestry and urban biomass are used for energy generation. The goal is to find and implement real-world solutions leading to local energy self-sufficiency at the same time as it contributes to restructure the primary sector. The cooperative is involved in the financing of power production equipment, arranging and organizing the biomass logistics and supply chain, processing of resources to classify it into fractions with specific properties, to investigate the enhancement of properties, etc. The cooperative allows the	http://www.esek.gr/

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	Project and country	BM archetype	Key activities	Motivations, governance, ownership and operation	Link
				participation of all residents of Karditsa prefecture, who can become shareholders. The capital gathered from initial members (citizens and local firms), loans and financing programs was used to buy land to build the facilities. The project is supported by local entities (Chamber of Commerce, Regional Authority, Municipalities, Development Agency, Cooperative bank) and continuous negotiations with groups of interest (farmers, forest cooperatives, municipalities) are being established to increase and give stability to the business. The heat generated in the facilities is injected into the local heat distribution network and the cooperative's main source of revenue is the sale of heat although currently they are considering installing PV for self-consumption and selling surpluses.	
13	*Templederry community wind farm* (Ireland)	Energy cooperative	Renewable electricity generation and selling.	This community windfarm includes two windfarms to supply the grid with community-owned wind energy. The project is run by the 32 shareholders living in the locality and produces enough green electricity to power 3500 homes. The local community of Tipperary, Ireland was aiming to engage in wind energy as part of the 'Environmental Protection' goal defined by their Community Development Plan. Then, in conjunction with the Tipperary Energy Agency (TEA), they performed viability studies and installed three 1.3 MW wind turbines in June 2003 and two more of 2.3 MW in 2010. The goal is to generate electricity and selling it to the grid with dividends from the project being re-invested to support other community activities. The project is mainly governed by the TEA, a not-for-profit company (no shareholders). Non-remunerated directors, who are responsible for the governance of the organization, are nominated from representatives of member organizations and local experts.	https://tippenergy.ie/our-work/templederry-community-windfarm
14	*Sprakebüll Village* (Germany)	Energy cooperative	Renewable electricity (wind and solar) and heat (biogas) generation, supply and selling.	Sprakebüll was formed as a community wind farm project (5 windmills, each 1,65 MW) in 1998 by a group of 247 villagers. In 2011, the Stadum-Sprakebüll wind park was created with 3 more windmills and in 2014, the original windmills were replaced with ones producing 3,6 MW each. After the initial investment in the wind turbines, the community become interested in solar energy and in 2009 constructed a 100 MW PV installation. In addition to the production of wind and solar electricity, the villagers set up a district heating cooperative and with the help of the municipality received a pre-financing of investments, for a satellite combined heat and power system and heating network. The municipality leased it to the cooperative, to produce, supply and distribute both heat and electricity. Currently, the cooperative buys heat from the privately owned biogas plants in the village and distributes it via the heating network to the inhabitants. Every year, shareholders discuss the retained earnings and how much dividends are expected in the coming financial periods. All new projects must be submitted to the municipality and experts are advising the members in the various fields of legislative framework, financial consultancy and technical know-how, greatly aiding the decision-making processes. Voting rights depend on the proportion of capital invested (number of shares), not on the traditional "one member, one vote" cooperative rule as well as dividends distribution. Currently the project is owned by profit-driven local members, bank loans, the local municipality (earned capital is partly reinvested into the district heating network) and private partners.	http://co2mmunity.eu/wp-content/uploads/2019/02/Factsheet-Sprakeb%C3%BCll.pdf
15	*Ellhöfter wind park* (Germany)	Energy cooperative	Renewable electricity generation and supply.	Founded in 2007, the citizens' wind park includes 7 turbines with a capacity of 27.5 MW, allowing the system to power 18,750 households in the region. Three hundred citizens of the local communities around Schleswig Holstein, in northern Germany, came together to finance these assets, creating jobs and supplying their community with renewable energy. The shareholders – local residents– are collectively responsible for the running and management of the wind park, with the help of technical experts. The revenues attained from the cooperative are translated into donations in kind to the community of Ellhöft.	https://windpark-ellhoeft.de/

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	Project and country	BM archetype	Key activities	Motivations, governance, ownership and operation	Link
16	*Bioenergiedorf Jühnde (Germany)*	Energy cooperative	Renewable electricity and heat generation and supply.	Jühnde is a village involved in local renewable electricity generation and heat generation and supply through wind, solar, biomass and biogas. The cooperative created in 2005 and with 1089 members is able to produce annually 5 MWh of electricity and 4.5 MWh of heat (3.5 MWh are used in local households). The village aims to become a bioenergy village, aiming to reach some level of energy (electricity and heat) autonomy. The project was started as part of a research project by the Universities of Göttingen and Witzenhausen in 2001, which helped the initial financing of infrastructures. In 2005 the cooperative was created to run the biogas plant which also includes the management of a district heating network, a wood chip heater and two heat storage systems, as well as a photovoltaic system and a wind turbine. In 2015, the project was repowered. Part of the villagers became shareholders, along with other partners and the municipality, and currently the daily activities of the cooperative are managed through a board where villagers, partners and municipality are represented. Energy is supplied locally, and dividends are reinvested in the village.	http://www.bioenergiedorf.de/
17	*Elektrizitätswerke Schönau (Germany)*	Energy cooperative	Renewable electricity and heat generation and supply.	The multi-utility cooperative was created in 2009 and has 7300 members. It is involved in the generation, supply, distribution of renewable electricity; supply and distribution of heat (district heating); bio and natural gas supply and distribution; supply of energy and e-mobility services by using wind, solar, biomass, biogas and combined heat and power technologies. The cooperative also performs activities regarding electricity network operation and energy management. Members are financially involved in the cooperative and are economically benefited from energy selling revenues.	https://www.ews-schoenau.de/
18	*Edinburgh Community Solar Limited* (The United Kingdom)	Energy cooperative	Energy generation, self-consumption, operation and surplus selling.	541 cooperative members financed the installation of solar systems in the roofs of 24 City of Edinburgh Council buildings. During operation, some or all the electricity generated is used by the building, being the cooperative remunerated by that. The cooperative also receives income through feed-in-tariffs by any surplus electricity exported to the grid. Currently, an installed capacity of 2 MW is installed in Edinburgh public buildings, schools, community buildings and leisure centers. The cooperative is run by a board of twelve directors: seven elected members, three representatives of the City of Edinburgh Council and two co-opted individuals whom the rest of the board have agreed to appoint.	https://www.edinburghsolar.coop/
19	*Brixton Energy* (The United Kingdom)	Energy cooperative	Energy generation, self-consumption, operation and surplus selling.	The project was set up by the Repowering London, a renewable energy provider in cooperation with independent charitable trusts, community-based movements and the Lambeth Council. Three community solar energy projects were implemented in Brixton public buildings, generating renewable energy and bringing financial revenues into the local neighborhoods where they are sited. Each project is a registered cooperative exclusively owned by its shareholders, who paid £250 for projects shares. The sale of these shares helped to finance the installation of generation systems. The electricity generated is first sold to users within the buildings, and the excess is sold on to the power grid. Investors receive interest rates, whilst part of the profits are returned to a Community Energy Efficiency Fund and spent on a variety of local initiatives. Seventeen directors (including but not exclusively from Repowering London) constitute the board, bringing expertise on energy efficiency, renewable energy, research, project management, journalism, engineering, web development, communications, finance and business development.	https://brixtonenergy.co.uk/
20	*Eigg Island community project* (The United Kingdom)	Energy cooperative	Energy generation, self-consumption, supply, storage, distribution and daily operation.	The Isle of Eigg is the world's first standalone energy grid powered entirely by renewables. In 2008, the Eigg Electric became operational, providing reliable and renewable energy supply to the islanders. Households and businesses on the island are connected by an underground cable to energy generated from three sources: hydroelectric, wind and solar. A battery bank capable of providing electricity for up to 24 h hours helps smooth out supply and demand, and two diesel generators are	http://isleofeigg.org/

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	Project and country	BM archetype	Key activities	Motivations, governance, ownership and operation	Link
				used for back-up. The running cost of Eigg Electric is covered through income from an off-grid feed-in tariff, Renewable Obligation Certificates and a local energy tariff for residents and businesses. Eigg Electric is a subsidiary of the Isle of Eigg Heritage Trust set-up in 1997 by Eigg residents, the Highland Council and Scottish Wildlife Trust in order to buy the island. The trust is governed by a voluntary, elected board of directors comprising 4 Eigg residents, one member each from the Highland Council and Scottish Wildlife Trust and an independent chair.	
21	*Som Energia* (Spain)	Energy cooperative	Energy generation, supply, and daily operation.	This is a non-profit cooperative involved in renewable energy generation including PV, wind, biogas and biomass sources. The cooperative has different facilities for generating electricity, generating currently around 10 GWh per year and currently involves more than 68,000 members. It finances its own renewable projects through voluntary financial contributions from partners. The cooperative members belong to the initiative thanks to an initial contribution to the share capital of 100 EUR. Local cooperative managers (with headquarters at strategic points throughout Spain) are democratically designated, being responsible for the daily management of the systems. However, technical staff are hired to guarantee technical and regulatory issues, economic viability and the inclusion of new members.	https://www.somenergia.coop/
22	*Spółdzielnia Nasza Energia* (Poland)	Energy cooperative	Construction of interconnected networks to collect biogas, construction of generating units, supply of heat for commercial and residential buildings and self-consumption.	This cooperative is the first initiated in Poland and it has 300 members. Currently it is solely involved in renewable heat and electricity generation though biogas power plants. The main goal is to supply electricity and, if possible, heat for public buildings and households. The cooperative owns the local distribution grids, allowing for the energy offered being 20% cheaper than that drawn from the national power system. Part of the required investment came from the cooperative itself through equity funds, resource fund and business revenue, and the rest is covered by subsidies and commercial loans. The BM governance belongs to the cooperative board, composed by 5 key elements responsible for different development areas. Each member, that doesn't necessarily have to be local, regardless of the number of shares held, has one vote at the general meeting. Members benefit from the project by participating in the cooperative's profits, the possibility of influencing the key decisions of the cooperative, electing and being elected to cooperative bodies. Also, the share in the balance sheet surplus is proportional to the increase in the cooperative's assets during the period of holding a given share. Thus, the earlier a share is bought, the more profit will generate.	https://www.gramwzielone.pl/bioenergia/11409/spoldzielnia-nasza-energia-powstaje-pierwsza-w-polsce-spoldzielnia-energetyczna
23	*Coopérnico* (Portugal)	Energy cooperative	Renewable energy financing, generation and supply.	Founded in 2013, Coopérnico is a renewable energy cooperative that joins solar power for benefiting the local community. The cooperative rents the roofs of institutions for its PV projects, providing them with extra income. At the end of the lease, the cooperative will offer the generation assets to the hosting institutions for free. The adhesion to Coopérnico is made through the purchase of at least 3 equity titles, in the amount of 60 EUR. These titles have no fixed remuneration and can only be remunerated if there is a distribution of surplus resulting from the activity. Members can participate directly in renewable projects, making savings while protecting the environment and supporting social solidarity projects. They can also use the services of the cooperative, present proposals and ideas at the General Assembly and elect and be elected to the Cooperative management board.	https://www.coopernico.org/

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24	*Amelander Energie Coöperatie* (The Netherlands)	Energy cooperative	Renewable energy generation and supply.	With 286 members, the island cooperative created in 2009 is involved in renewable electricity generation and e-mobility services (car-sharing running on solar). The cooperative owns a solar park with 23,000 solar panels, capable of supplying all the Ameland households. As the cooperative does not have a supplier's license, the invoicing is done through other licensed suppliers. Members can contribute with ideas, participate in discussions and participate in decisions about the local future. The goal is to reach energy self-sufficiency, to stimulate the reduction of energy consumption on Ameland (through behavior and energy-saving measures) and to generate the energy consumption that is necessary sustainably via solar, geothermal and tidal energy. Members are involved by buying one-member certificate (50 EUR) up to a maximum of 500 and each member has 1 vote regardless of the number of certificates. The share capital is invested in projects and dividends ate paid on the depositary receipts if a majority of the members so wish.	https://www.amelandenergie.nl/files/info.htm
25	*Duurzaam Ameland* (The Netherlands)	Energy cooperative	Energy generation, supply and distribution, energy efficiency and e-mobility services.	This cooperative was created as a public-private partnership between the municipality of Ameland, in The Netherlands, companies as Eneco, GasTerra, NAM, Signify, Liander, TNO and the EnTranCe research center of the University of Groningen. Started in 2007, this project was firstly established to supply and distribute renewable energy to Ameland citizens, but today EE; public lighting and electric collective mobility services are also exploited by the company. The cooperative owns a solar park capable of generate annually about 14.67 GWh and is also involved in co-generation. The project was initiated as part of a research project and currently is governed by local members representatives and the remaining partners. Profits are locally reinvested.	https://www.duurzaamameland.nl/
26	*De Windvogel* (The Netherlands)	Energy cooperative	Energy generation and selling.	Is a Dutch energy cooperative of 3300 citizens and other legal entities founded in 1991, owning four wind turbines and two solar parks with a total installed capacity of 22 MW and selling generation to the grid. De Windvogel membership have a fixed cost (50 EUR) and apart the membership fee, members can make voluntary donations which are used for maintenance and acquisition of new technologies. Members receive a financial return determined annually by a cooperative general assembly (expected interest of 2–5%) as well as clean energy in a maximum of 3500 kWh per year. An external energy supplier provides the remaining energy. Members participate in the project by jointly contributing financially to projects and sharing the proceeds together.	https://windvogel.nl/
27	Litoměřice (Czech Republic)	Community prosumerism	Energy generation, energy efficiency, self-consumption, and surplus selling.	The city administration boosts the installation of PV assets in private houses and public buildings. Thus, with the collaboration of the SCORE pilot-project, PV systems were installed, and energy efficiency measures were implemented in order to reduce the buildings energy consumption. The pilot project aims to raise the capacity of existing installations by 1.5 MWp and to involve more 250 households as (co-)owners of PV facilities. The surplus energy will be used for public and administrative buildings. Local households and the municipality are deeply involved in the financing and implementation of this project.	http://energy-cities.eu/members/city-of-litomerice/
28	*Svalin community* (Denmark)	Community prosumerism/LEM	Renewable energy generation, self-consumption and selling.	An example of prosumerism in communities has been exploited in Svalin, a Danish community of 20 households purposely designed to accommodate solar panels, geothermal heat pumps and EVs. The community is energy positive, meaning that it produces more renewable energy than it consumes on a yearly basis. Thus, households consume their electricity generation and surpluses are redirected to the electric grid under current Danish regulatory	https://the-energy-collective-project.com/context/

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				framework. The community aims to be self-sufficient, thus local energy trading possibilities are being studied to allow household to trade their surpluses locally.	
29	*Solar community energy project in Recklinghausen (Germany)*	Community prosumerism	Electricity generation and selling.	The project aims to take advantage of the many public roof surfaces in cities which can be used for generating electricity. The citizens of Reklinghausen decided to exploit this potential with a community power project and the city supports the initiative by leasing the roof surfaces for the PV cells. Three PV systems were installed, producing around 195,000 kWh of electricity per year, which allow to supply around 60 households with electricity the whole year. The project was 100% financed with own capital resources. In average, each citizen invested around 3300 EUR. The generated electricity (enough to supply around 60 households the whole year) is injected directly into the power grid. Shareholders are involved in the project day-to-day decisions and revenues from energy injection are used to reimburse individual investments.	http://www.sola-re.de/
30	*sonnenCommunity*	LEM	Electricity generation, storage and sharing activities	This community of interest running in Germany, Austria, Switzerland and Italy involves prosumagers in generation, storage and sharing activities. sonnenCommunity members use energy from the community exclusively. Individual PV systems completely cover members energy needs and any surplus is fed into a virtual energy pool to serve other members. A central software platform links all the members and balances energy and supply. Members are charged a monthly membership fee of 19.99 EUR. They also must support all the technology costs. In turn, they receive an extended battery guarantee, low-priced energy from the sonnenCommunity, software updates, weather forecast updates, energy usage optimization to match weather forecasts and remote maintenance and monitoring.	https://sonnengroup.com/sonnencommunity/
31	*Bostadsrättsföreningen Lyckansberg (Sweden)*	Community collective generation	Energy generation, sharing, daily operations.	Created in 2018 by 85 tenant-owned apartments, this project is involved in renewable electricity generation through a co-owned solar plant of 53 kW. The collective system generates electricity for common purposes, such as lighting, laundry cabins, sauna and other functions in the building. In case of surplus, PV electricity is sold online and if demand is higher, electricity is bought from the grid. The project is also involved in small-scale district heating supplied by a biomass system. The association has been granted 30% in support of the investment from the state solar cell grant.	https://www.hsb.se/sydost/brf/lyckansberg/miljo/solceller/
32	*Solbyn Association* (Sweden)	Community collective generation	Heat water generation, sharing, daily operations.	Created in 1988 by 50 households, the project was initiated by a highly educated, environmentally concerned citizen group living in a multi-tenancy environment. The community is involved in renewable heat generation through solar heating and heat exchange systems and savings are used to implement EE activities as buildings insulation. The project is fully developed, implemented and financed by users who organize themselves to deal with administrative functions with boards, interest groups and housing groups.	http://www.solbyn.org/about
33	*Solar roof* (Bulgaria)	Community collective generation	Energy generation, sharing, daily operations.	It was created as a community of place by a homeowner's association of an apartment block in Sofia under the scope of the ENERGISE project. Users came together to plan and install a rooftop solar power installation. All the building's residences are signed up to the community project, with a capacity of 28.2 kWp. The scheme is expected to produce 35 MWh of electricity annually, representing about 5–7% of the total consumption in the building. Governance is the responsibility of the project participants, who are also investors and customers. Direct revenues from energy selling are not expected but projects costs are shared.	https://www.zazemiata.org/

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34	*Chase Community Solar* (The United Kingdom)	Community ESCO	Energy generation, self-consumption, and surplus selling.	This project is based on customized PV solar panels and control technologies installed in homes owned by the Cannock Chase District Council. The goal is to maximize the benefit from local PV generation, new battery storage and smart technologies, putting a community ESCO at the center of the relationship with residents. Smart technologies installed in each home switch customers' electricity supply between local solar, battery storage and the grid. They also send data to a central software platform, the community ESCO, which will partner with a licensed supplier to provide each home with all its energy needs. The project is composed by its members (shareholders) who financed it, but the addition of funds from a loan by an ethical provider should also be recognized. Investors are reimbursed through feed-in-tariffs received from selling to the grid the electricity not used by the residents. If there is any further surplus, this will be directed into a community fund for local benefit.	http://chasesolar.org.uk/
35	*Som Mobilitat* (Spain)	E-mobility cooperative	Electric car-sharing.	This Spanish mobility cooperative aims to provide sustainable solutions for e-mobility. Its BM focus on providing rental service of electric cars (car-sharing), with EVs which can be either owned by the cooperative or by individuals, enterprises and public institutions. It is also expanding the model to include services such as bike-sharing, motorbike-sharing or car-pooling. The cooperative is constituted as non-profit and its activity focuses on the networking with other cooperatives and cooperating with public bodies and local investors, involving them as partners and funders of local projects. The assembly brings together all the members and is the highest decision-making body of the cooperative, following the logic of 'one person, one vote', regardless of the size of investment. The voluntary Governing Council is elected by the members and is responsible for implementing the guidelines set by the assembly and the statutes of the cooperative. Members can buy as many shares as they want (single contribution of 10 EUR) and in return they can enjoy the cooperative's services corresponding to the amount invested.	https://www.sommobilitat.coop/
36	*Mobicoop* (France)	E-mobility cooperative	Shared mobility activities and public transportation services.	The cooperative created in 2011 and with about 20,000 members is mainly involved in shared mobility activities, including car-pooling, car-sharing, shared bikes and public transportation services using electric vehicles. The cooperative is a collective interest cooperative, meaning that anyone sharing the same goals can become member by subscribing shares. The minimum subscription is set at 1 unit (100 EUR), without a limit on the number of units. The commitment is for five years. At the end of this period, members can ask the cooperative to buy back their share(s). Becoming a member confers the right to participate in General Assemblies with the basic principle of 'one person, one vote' and to choose the members of the Board of Directors. Governance is determined by the Articles of Association and the Internal Regulations and the project is financed by the shares acquired by the cooperative members and by the services provided to users.	https://www.mobicoop.fr/

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