Politecnico di Milano
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Energy Communities: State of the Art and Business Models Analysis for Energy Market Players

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Ringraziamenti

Ciao Andrea, scrivi queste parole con almeno due anni di ritardo da quando avresti voluto scriverle alla conclusione del lavoro di tesi dopo un "normale" percorso in questa Laurea Magistrale. Nel mezzo sono successe tante, troppe cose, per cui la persona che sta scrivendo oggi non è la stessa che le avrebbe scritte in quell'ormai lontano Anno Accademico 2019 – 2020. Non è la stessa perché il tempo e le esperienze ti cambiano, si cresce, ci si conosce meglio e forse si matura. Ad ogni modo, ricordati di non pentirti di una singola scelta che hai fatto in tutto questo, perché dopotutto una laurea in ritardo non definisce nessuno, ma tutte le avventure e difficoltà affrontate ti hanno portato dove sei adesso. Dopo aver concluso tutti gli esami, con l'eccitazione di un esploratore che parte verso l'avventura hai deciso di partire per l'esperienza enorme che è stata l'Africa, in quell'Uganda che dopotutto porterai sempre dentro come un luogo un po' speciale, con le persone che hai incontrato e quella cicatrice sul polso destro che sta a ricordarti ogni giorno quanto in fondo, nella sfortuna, sei stato fortunato. Poi è arrivato il Covid, un rientro a casa di fretta in quel marzo 2020 dove hai ritrovato l'Italia intera in ginocchio, in un clima post apocalittico e gli ospedali pieni. La dura decisione di mollare quel progetto di tesi e cambiare, ancora inconsapevole che quello fosse solo uno dei capitoli di questo lungo viaggio fino ad oggi. Poi hai trovato questo progetto di tesi, per cui un grosso ringraziamento va al Prof. Franzò e la sua disponibilità. Pensavi che la salita fosse finita, che fosse il momento di lasciarsi alle spalle tutto quel periodo così particolare. Al contrario, il tuo vero viaggio è iniziato, in cui hai conosciuto cosa vuol dire lo sconforto, il sentirsi demotivato al punto di mettere in dubbio le tue capacità mentre ti trascinavi nei mesi senza concludere un bel niente. Hai pure cambiato due lavori nel frattempo, forse in cerca di autonomia dai Tuoi, ma sicuramente per ritornare nel mondo delle persone che fanno. Hai incontrato Matteo e Luisa che hanno creduto in te e grazie a loro hai capito cosa vuol dire il lavoro, l'essere parte di un Team fuori dall'università che cerca di lanciare una brillante idea sotto formato di azienda, grazie Ragazzi. Credo sia anche per questo ritorno alla vita "normale" che io sia qui oggi, perché ritrovare stimoli e convinzione nelle proprie capacità in orario di lavoro ha permesso di ritrovare la strada verso questa Laurea.

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Abstract

The study is based on the concept of the energy community, investigating the business models that market players can implement to seize the opportunities opened up by this innovative model of energy production and consumption. The objective is to create a framework to better understand how different companies can operate in this new market, highlighting the peculiarities of each BM and discussing their potential in terms of business sustainability.

The concepts of Energy Community and Collective Self Consumption are explored. This is important to understand both the benefits and challenges of their implementation, the enabling technologies, the different configurations and their peculiarities. The state of the art is then presented with some interesting projects on a national scale, with the aim of highlighting evidence of their potential put into practice. Subsequently, broadening the perspective to the European Union, an overview of the legislation of some member states is provided to highlight the direction in which the transposition of EU directives is heading.

The business models that can be adopted by operators are analysed. In particular, the analysis focuses on the activities that can be carried out by third parties to create and manage collective self-consumption and Energy Community configurations. The business models adopted by "third parties" interested in contributing to the creation and management of collective configurations of self-consumption and Energy Community, identified from the scope of activities managed.

Finally, it is proposed to provide an overview of how energy bigwigs relate to energy communities to investigate the potential winning development model. More in detail, an analysis will be made of the Hera and A2A groups.

Sommario

Lo studio si basa sul concetto di comunità energetica, indagando sui modelli di business che gli attori del mercato possono implementare per cogliere le opportunità aperte da questo modello innovativo di produzione e consumo di energia. L'obiettivo è quello di creare un quadro di riferimento per comprendere meglio come le diverse aziende possono operare in questo nuovo mercato, evidenziando le peculiarità dei Business Models individuati e discutendo del loro potenziale in termini di sostenibilità aziendale.

Vengono approfonditi i concetti di Comunità Energetica e Autoconsumo Collettivo. Questo è importante per comprendere sia i vantaggi che le sfide legate alla loro implementazione, le tecnologie abilitanti, le diverse configurazioni e le relative peculiarità. Viene poi presentato lo stato dell'arte con alcuni interessanti progetti su scala nazionale, con l'obiettivo di evidenziare le prove del loro potenziale messo in pratica.

Successivamente, allargando la prospettiva all'Unione Europea, si fornirà un quadro delle legislazioni di alcuni Stati membri per evidenziare verso quale direzione sta andando il recepimento delle direttive comunitarie.

Vengono analizzati i modelli di business che possono essere implementati dagli operatori di mercato. In particolare, l'analisi si concentra sulle modalità di creazione e gestione di una configurazione collettiva di autoconsumo e di comunità energetica, ovvero sulle attività che possono essere svolte da terzi per creare e gestire tali configurazioni.

Infine, si propone una panoramica su come i big dell'energia si rapportano alle comunità energetiche per investigare il potenziale modello di sviluppo vincente. Più in dettaglio, verrà fatta un'analisi dei gruppi Hera e A2A.

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1. Introduction

1.1 Global Picture

Last two years have been the most challenging years from the post-war period to date due to the sadly-known pandemic crisis affecting the entire planet without any exception. At the same time, there is a silent threat which is growing up year-by-year and it will forcedly grab our attention for decades to come, climate change. Relating the concept to the widespread use of fossil fuels, it means CO2 emissions coming from combustion processes and the consequent raise of the global average temperature. In 2007, the Nobel Peace Prize Al Gore said that "global warming is the greatest challenge mankind ever faced" [1], warning the world about this global issue and put it under the spotlights. Today we can say that resounding statement was somehow true, reflecting the magnitude of such a threat. Climate change has some similarities with the outbreak going on today, in particular regarding the global scale of the problem: there are no borders, there are no alternatives than winning against it to survive, it requires international alliance and cooperation, everyone is involved and the final outcome depends on the behaviours of every single person on the planet.

Within the energy sector the action to tackle climate change passes through the implementation of renewable energy sources for a sustainable provision of electricity for final consumption. In the past, power has mainly been generated by large centralized plants using non-renewable fossil fuels. Nowadays times are changing, there are some megatrends going on which will shape the future energy sector by blending together the need for sustainability and innovation:

- *Distributed generation*, meaning the shift from big centralized plants to many small-scale production sites spread throughout the territory, where every consumer becomes an energy producer by installing production units in his property, such as solar PV or small wind turbine. In this way, he is able to contribute to the power supply for himself and the whole grid. For this new actor a new term has been defined, *prosumer*, highlighting the dual role of producer and consumer (figure 1);

- *Energy efficiency*, that means using the available energy in a better way through the adoption of more efficient technological solutions which allow to lower the energy consumption;
- *Smart energy*, concept that encompasses all the digital technologies available on the market today, which open many opportunities for monitoring and smartly managing the components of a grid that is more and more interconnected;
- *Electrification of consumptions*, as renewables become more convenient than other energy sources and the cost of batteries for energy storage decreases we see the diffusion of electric vehicles and other technologies which previously were not based on the use of electricity;

The result determined by the mentioned trends is a constant force of change leading to a gradual penetration of renewables, with a global picture showing Europe, USA and Cina as the leading players within the energy transition process.

During 2020, as presented by the International Energy Agency, the share of renewables within the global electricity demand was expected to reach 27%, growing a record 2.3% from 2019 thanks also to a contraction in the overall demand due to the pandemic crisis. By the end of 2025, the electricity generation is expected to reach a 33% share surpassing the historical coal-fired generation [2].

Figure 1 - Comparison between consumer and prosumer models. The latter presents RES installations, may supported by storage to increase the self-consumed energy, determining bi-directional flows with public grid. (source: ENEA (2020), Le comunità energetiche in Italia

To demonstrate the commitment for enhance sustainability, many countries and international institutions set goals in terms of share of RES, energy efficiency and other measures with different time horizons. In September 2015, the United Nations General Assembly approved the *2030 Agenda* which is a program to take action to ensure humans' well-being, environmental stewardship and prosperity. The agenda has been signed by 193 countries and it incorporates 17 *Sustainable Development Goals* [3] covering several fields, from fighting against poverty to ensuring justice and peace. In particular, goal number 7 is about "Affordable and clean energy", with the aim to solve the *Energy Trilemma*:

1. *Energy security*, in terms of energy supply, reliability of energy infrastructure, and ability to meet both current and future demand;
2. *Energy equity*, providing access and affordable energy supply across population;
3. *Environmental sustainability*, to be reached with energy efficiency and development of renewable and low-carbon energy supply;

Just few months later, in December 2015, the COP21 Paris conference composed by 196 countries adopted the *Paris Agreement* [4] a treaty based on the shared commitment to keep global temperature from rising more than 2°C compared to pre-industrial levels. Looking to European Union, the long-term strategy has been defined to comply to the commitment of the *Paris Agreement*. In November 2016, European Commission published the "*Clean Energy for all Europeans*" package with the commitment to reach carbon neutrality by 2050 [5] and, besides other proposals regarding several fields, a target share of 20% for RES in the EU's energy mix by 2020 and at least 32% by 2030. Member States must then translate these goals into internal directives with the aim to stimulate RES installation. Among the 28 EU Member States, 12 countries have met the 2020 goal [6] and Italy it's among them, despite a lot of work is still needed in order to meet 2030 target by EU as a whole.

The Italian picture shows an increasing penetration of RES in accordance to the goals set by *PNIEC* [7]. Italy aims to pursue a target of covering 30% [8] of gross final energy consumption from renewable sources by 2030, establishing a path of sustainable growth of RES with their full integration into the system. New installations in 2019 reached 1211 MW, growing 4% compared to the previous year. RES overall installed power is 55,2 GW [9], counting for a 45% share within national generation capacity. New installations are mainly driven by solar PV and wind, as shown in figure 2, which are the most naturally exploitable sources in Italy, particularly in the south with prevailing sunny weather and a significant number of useful hours for wind production throughout the year. In 2019, renewables covered the 35.6% share within the national electricity demand, highlighting an interesting scenario in terms of penetration that is bound to increase within the transition process towards a sustainable energy system. The value of the market connected to solar PV installations in 2019 was 850 million €, while wind power accounted for 450 million €. Investments within the green sector are expected to grow in the next decades also strengthen by favourable frameworks created by National Governments and international alliances, thus representing one of the most attractive markets in which operate.

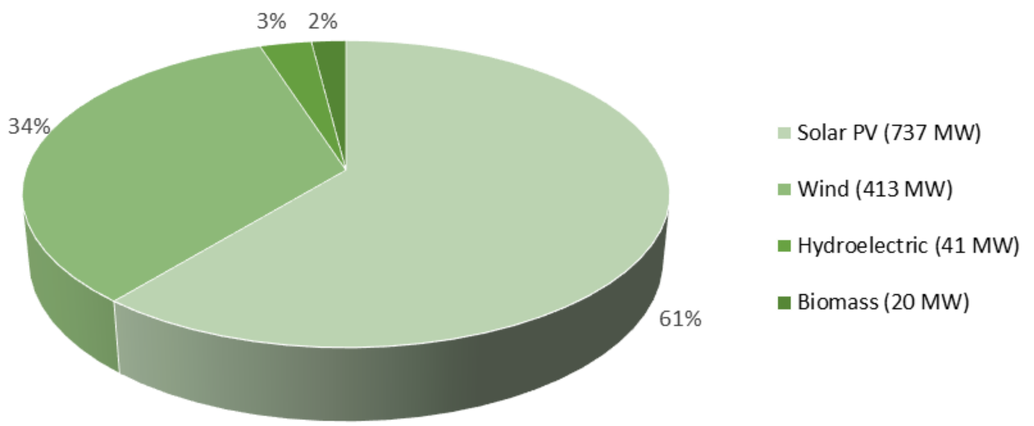

Figure 2 - Breakdown of 2019 RES installation in Italy [9];

1.2 A new paradigm for energy consumption

Given the picture described in the previous paragraph, it is clear that we are gradually entering a new era for energy markets where new opportunities arise and the model for energy consumption as we know is bound to change. Technological development brings innovative products which contribute to the digitalization of energy, improving the way it is produced, transferred, monitored and consumed. An evolving scenario where market players, from the historical utilities to the most advanced ESCos, strive to cope with the emerging trends, defining new models to run business within the energy sector which in the past was only about selling electricity to the final user as a commodity without space for differentiation. Today the game field is completely changed and is in constant transformation. We see differentiated commercial offers designed by companies coming from unrelated fields, such as energy production or software development.

Looking to demand side, consumers' habits are evolving as well. This comes from the trends which are shaping their choices towards different behavioural patterns. Over the last decade, we have seen sharing economy arising as a new model to get access to products or services, or in general to get people's needs satisfied. In some cases, the concept is to pass from the ownership of a product to the payment for a service provided by a company which substitute it, while in others there is sharing of resources which are owned by one or more individuals. Another element affecting people's culture is the call for sustainability, which is gaining more and more attention resulting in the wide presence of green products, from supermarkets to electric vehicles, and the willing to install domestic production systems based on renewables. Moreover, clients are becoming more aware of their consumption and they are willing to take control on their energy expenses. The future scenario will be characterized by a central role of prosumers within the transition to a more sustainable and efficient energy system.

As a result of the ongoing transformations on both market and demand side, incorporating together the trends within the energy industry mentioned in the previous paragraph, in the last years a new paradigm for energy production and consumption has emerged. This refers to a group of individuals, or legal entities, who decide to share their production plants and aggregate their consumption as a unique final user. The concept is known as *Collective Self-Consumption* or *Energy Communities* depending on the scale of the project and other peculiarities that will be analysed later on.

To introduce the concept a comprehensive definition is the following:

"Energy Community can be defined as set of energy users who decide to make common choices to feed their energy needs with the aim of maximizing the benefits deriving from this participatory approach; it can be implemented through distributed generation solutions and intelligent management of energy flows." [10]

According to the characteristics of the system, it is possible to find different definitions such as Renewable Energy Community or Local Energy Community. The first one highlights the real potential for ECs implementation that comes with RES plants exploitation, opening big opportunities for improving the sustainability of power supply, while the second one relies on the concept of proximity of members, exploited resources and strengthen of local economy. ECs can play a central role in achieving the long-term goals set by authorities and institutions, gaining in the last few years attention and recognition.

"Community led initiatives based on local collaborative solutions that can be set up by individuals, groups of individuals, households, small businesses or local authorities that operate individually or in an organized way are often referred to as 'local energy communities. These communities are expected to play an important role in the energy transition as they can enable the development of sustainable energy technologies and bring a variety of benefits to local communities." [11]

In recent years, legislators at European and national level have been striving to define laws and regulations that can serve as a solid foundation for the development of Energy Communities in the near future. According to the European Commission, European energy communities will have more than 100 GW of installed capacity by 2050, mainly consisting of wind and solar power plants [12]. These systems represent an opportunity to create new forms of collective action and collaborative economies, in which production and consumption give rise to new systems of exchange, combined with the opportunities offered by new digital technologies. They can represent the cornerstones of the energy transition, as well as an opportunity for the creation of new green economy models.

1.3 Research structure

The study is grounded around the concept of energy community, investigating the business models which market players can implement to take the opportunities open by this innovative model for energy production and consumption. The aim is to the create a framework to better understand how different companies can operate in this new market, highlighting the peculiarities of each BM and discuss about their potential in terms of business sustainability.

In *chapter 2*, the concept of EC and CSC are deepened. This is important to understand both the advantages and challenges connected to their implementation, the enabling technologies, the different configurations and related peculiarities. Then, the state of the art is presented with some interesting projects at national scale, the aim is to highlight the evidence of their potential put in practice.

Chapter 3 is about the regulatory framework regarding Energy Communities and Collective Self Consumption which is in constant definition, aiming to cope with the evolving market scenario defined by the trends affecting energy sector., the focus is put on the Italian framework, the legislative baseline for deepening into the object of the study: how to operate in the National market. Then, by widening the perspective to European Union, a picture of some Member States' legislation will be provided to highlight towards which direction the transposition of Community's directives is going.

Chapter 4 aims to analyze the business models that can be adopted by operators. In particular, the analysis focuses on the activities for the creation and management of a collective self-consumption and Energy Community configuration, i.e., the activities that can be carried out by third parties in order to create and manage collective self-consumption and Energy Community configurations. The business models adopted by "third parties" interested in contributing to the creation and management of collective self-consumption and Energy Community configurations, identified from the scope of activities managed. The breadth of supply, understood as the degree of "coverage" of current market supply with respect to the technologies and activities that fall within the scope of an Energy Community.

Chapter 5 aims to give an overview on how energy bigwigs are dealing with energy communities. More in detail we will make an analysis of Hera and A2A groups.

2. Energy Communities[1]: state of the art

2.1 Technological aspect

Technological advancement is a continuous process which impacts every sector, and energy is no exception especially given its technology-intensive nature. Shared energy, aggregation, loads optimization and flexibility are concepts whose foundations are bound into the new era of power production and consumption enabled by the smart energy phenomenon, meaning the gradual introduction of smart technologies thanks to which new operations and services are possible. The transformation is based on the evolution of technology in the fields of:

- Distributed generation;
- Storage;
- Intelligent management of networks and infrastructures through field devices and dedicated software;

As shown in figure 3, innovation will frame a new paradigm for the power sector with consistent changes impacting every stage:

- Production;
- Markets;
- Transmission;
- Distribution;
- Consumption;

[1] In this chapter, when not specified, with the term "Energy Community" reference is made for both Energy Community and Collective forms of Self-Consumption

The evolution paves the way for innovative energy management models. Energy Community and Collective-Self Consumption emerge as the presented new infrastructure is implemented alongside the support by legislation, affecting demand side of the market with empowered prosumers having the opportunity to aggregate their energy needs. This represents an important shift in the status-quo, moving from an individual approach to a collective one. The spread of self-consumption of renewable energy set the framework for these aggregated entities that act collectively, and which technically could already today operate in synergy according to a "community" logic based on the exchange of two-way energy flows.

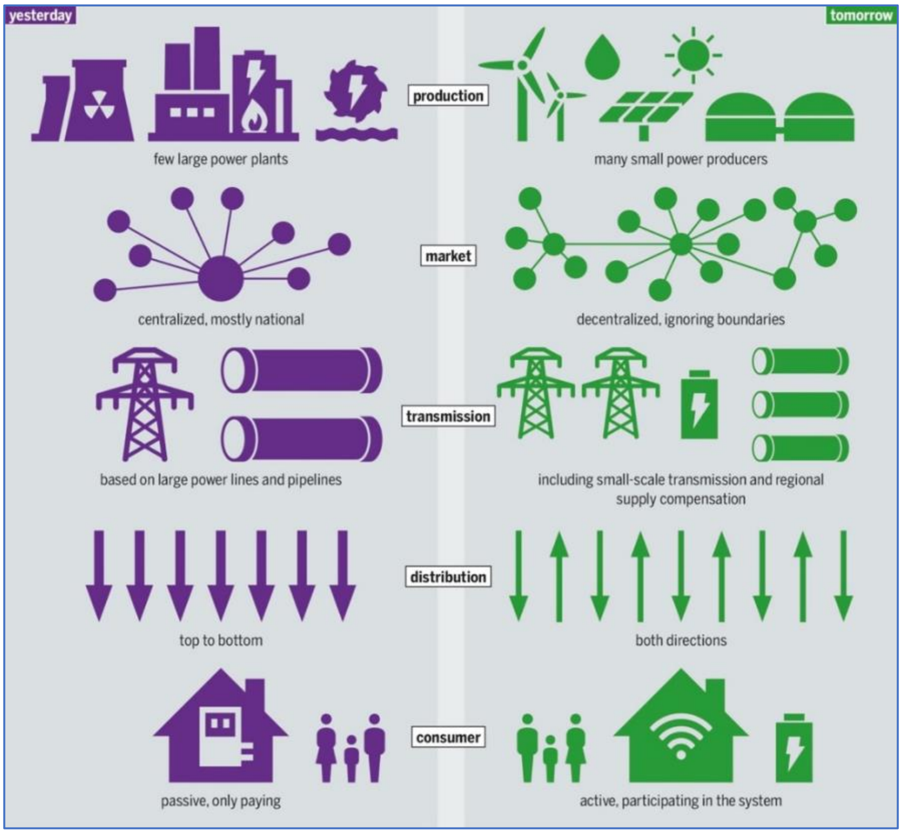

Figure 3 - End-use energetic paradigm as it was, on the left, and as it will be, on the right, defined through the ongoing transition towards an integrated smart energy system. The latter is the enabling infrastructure for configurations based on aggregation such as energy communities [13];

Following a necessary regulatory evolution to support such configurations, which is analyzed in chapter 3, through Energy Communities there are many services enabled by dedicated technologies that these citizen-prosumer communities could provide:

- power generation through small-scale RES plants;
- local distribution by injecting electricity into the grid;
- sale of energy on dedicated markets;
- management of storage systems for time shaving between production and consumption in order to increase self-consumption;
- provision of flexibility services to the public grid, by acting as Balance Service Providers through aggregation and demand-response mechanisms;
- supporting electric mobility both through the use of electric cars as distributed storage and by making charging points available that use local renewable sources;

In planning phase to realize an Energy Community project, the choice to operate a service rather than another one leads to the definition of different configurations characterized by a specific set of implemented technologies. For every configuration, the primary goal is to maximize as much as possible the self-consumption to effectively exploit the on-site electricity production. To do so, considering the individual user's application, self-consumption from renewable electricity can be satisfied if certain energy-economic conditions are met:

- adequate production profile to satisfy a significant part of loads profile during the day and along the year;
- costs of kWh produced (including installation costs, maintenance costs, incentives, etc.) less than or equal to the cost of the kWh purchased from the grid;

In the practice, if all the electricity produced by photovoltaics, or other RES, is consumed by the user, the payback time of the initial investment is reduced thanks to the greater share of savings enjoyed. Unfortunately, it is often difficult for the user to use all the energy produced and, conversely, much of the energy used by the user is purchased from the grid. To tackle this limit, beyond energy storage installation which can lead to higher self-consumption rates, the shift from individual to collective self-consumption can represent a way for energy communities to "pool" electricity consumptions in order to maximize the on-site consumption.

2.2 Achievable benefits

Benefits which citizens, condominium, Public Administration or companies can achieve in setting up collective forms of self-consumption are several and of different nature: economic, environmental, and social.

Economic benefits are crucial to drive the diffusion of collective configurations by providing economic sustainability to the investments undertaken in this new market for energy consumption. These are the following:

- bill savings. The more the self-consumed energy, the more the reduction of the variable components of the bill such as" quota energia", grid charges and related taxes. This translates into a figurative gain due to the fact that self-consumed energy is cheaper than energy taken from the grid;
- incentives on "shared" energy within the configuration;
- valorisation of produced energy and fed into the grid. Production of energy with a photovoltaic system, or other RES plants, can be a source of income thanks to incentive mechanisms dedicated to the injection of exceeding energy within the National grid, i.e. Scambio sul Posto [14] or Ritiro Dedicato [15];
- Tax deductions, i.e. Superbonus 110% and Bonus Casa 50% (for more details, see section 3.2.2);

Environmental benefits are mainly connected to the fight against climate change and to make energy provision and consumption more sustainable. These concepts on one side encompass CO2 emissions reduction thanks to RES plants adoption, which are at the basis of energy communities. This is indeed one of the main reason public and regulatory authorities are pushing their diffusion. On the other side, they refer to the concept of energy efficiency. This means to use available energy in a better and more efficient way, avoiding useless waste of it. Energy efficiency can be achieved in different ways, for example with actions that have a managerial character, such as integrated management platforms and dedicated software which open many opportunities for smart energy management, but also thanks to plant substitutions that, for the same performance, reduce energy consumption, such as installation of modern boilers or heat pumps.

The third category of benefits for which energy communities can bring a positive contribution is the *social* one. First of all, these configurations give direct control and create awareness among citizens about their energy needs. This represents a kind of "democratization" of energy, putting end users at the centre of the stage. Collective aggregations rely on a collaborative model of economy, named sharing economy, based on collaboration among people, sharing and exchange of both goods and services. When it comes to the energy application, it means sharing energy production plants to supply consumption loads. It gets convenient both environmentally and economically thanks to the synergies which are created in assuming a collective perspective to satisfy energy needs rather than an individual one. Where applied, the social impact of this model becomes even more beneficial when the dimension of these economies gets local, by involving locally available resources and market players. In this way, energy communities can drive the strengthen of small economies and social fabric even in remoted and isolated areas. Moreover, collective aggregations represent an effective way to tackle energy poverty, included in the United Nations 2030 Agenda as one of the actions under the aforementioned Goal 7 "Ensure access to affordable, reliable, sustainable and modern energy systems for all [3]. All citizens, including the most vulnerable and those with low incomes, should be able to benefit from participation in an energy community. They can include forms of energy solidarity, providing their members with cheaper access to energy supply.

2.3 Existing configurations: European picture

The first energy communities emerged in Europe as early as the 1990s. They were mainly set up as cooperative societies with the aim of promoting the production and consumption of local energy and involving citizens in a new and rational use of self-produced energy in a shared way. Initially, most of the projects were launched as bottom-up initiatives lead by citizens, the main driver for their creation was indeed to meet energy needs of isolated communities. To date, tens of thousands of European citizens, companies and public administrations consume their own energy thanks to their participation in community energy projects. These realities are regulated and recognized at European level, thanks also to the latest directives on renewables RED II and EMD II (chapter 3.1) which have set the framework for their massive diffusion, and at national level where the transposition process of the European directives is underway (chapter 3.2). Today, the drivers to set up energy community projects can be various depending on pursued goals, players involved, enabling technologies and business models. This leads to the presence of different configurations which will be presented in the present section.

The following framework is provided to show the state of the art of community energy projects in terms of diffusion and different configurations, which is important as a baseline for the further investigation object of the present study. The market overview refers to the European picture as of the end of 2019, prior to the adoption of EU Directives by most of Member States. It is based on the results from the analysis conducted by Paola Boccardo in its research [16], for which this study is intended to be the prosecution with the focus on the economic evaluation of implementable business models for market players.

The results are presented according to the classification proposed by Gui and MacGill (2018) [17] which is reported in table 1.

Category	Definition	Goals
Community-scale energy project	Energy projects, promoted and financed by a community, which may concern, for example, the construction of renewable energy production plants, energy efficiency and conservation measures, energy services for the community.	• Reduced energy bill • Clean energy supply • Contributing to energy transition • Access to incentives • Social inclusion
Virtual Power Plant (VPP)	Virtual aggregation of programmable generating units, storage systems, and loads, which are managed to operate synergistically as a single plant in order to actively participate in the management of the National electricity network.	• Reduced energy bill • Contribute to grid stability • Improvement of grid efficiency • Capacity management for demand-response • Income generation from ancillary services
Peer-to-peer (P2P) Trading	Software trading platform, enabled by a smart electricity infrastructure, to allow exchanges between energy demand and production.	• Better exploitation of energy production assets • Creation of local market • Reduced energy bill
Community Microgrids	Autonomous and self-sufficient local energy supply system. It may be independent from public network or connected to	• Reduced energy bill • Energy self-sufficiency • Energy security

	a centralised grid, on a regional or national scale, which includes residential or other electricity loads and which may be supported by the high penetration of local distributed renewable plants or other distributed resources, including on the demand side.	• Management of local distribution • Maximization of benefits for local community
Integrated Community Energy Systems (ICES)	Integrated urban resource management system, not only for energy supply, but possibly also involving efficient buildings, cogeneration plants, water and sanitation, transport and waste management.	• Reduced energy bill • Increase in energy efficiency • Maximization of benefits for local community • Minimization of impact on the environment • Community empowerment • Synergies within local resources network

Table 1 - Description of classification categories of Energy Community cases with definitions and correspondent pursued goals [18]

The study was based on the analysis of about 350 cases framed within the definitions given in table 1. The distribution among Member States (figure 4) shows a high concentration of projects, almost half of them, within four countries: Germany, Netherlands, UK and Italy. The number of projects for each country has gradually raised starting from 90s, a trend which shows how the creation of such entities can represent a good answer to the need of managing energy in a structured and shared way in order to pursue objectives of economic, social and environmental sustainability. The recent definition of REC and CEC, beside CSC, introduced by EU RED II and EMD II directives to create a favorable framework for further diffusion of such projects is expected to be a boost for which new cases are expected to raise in the next years.

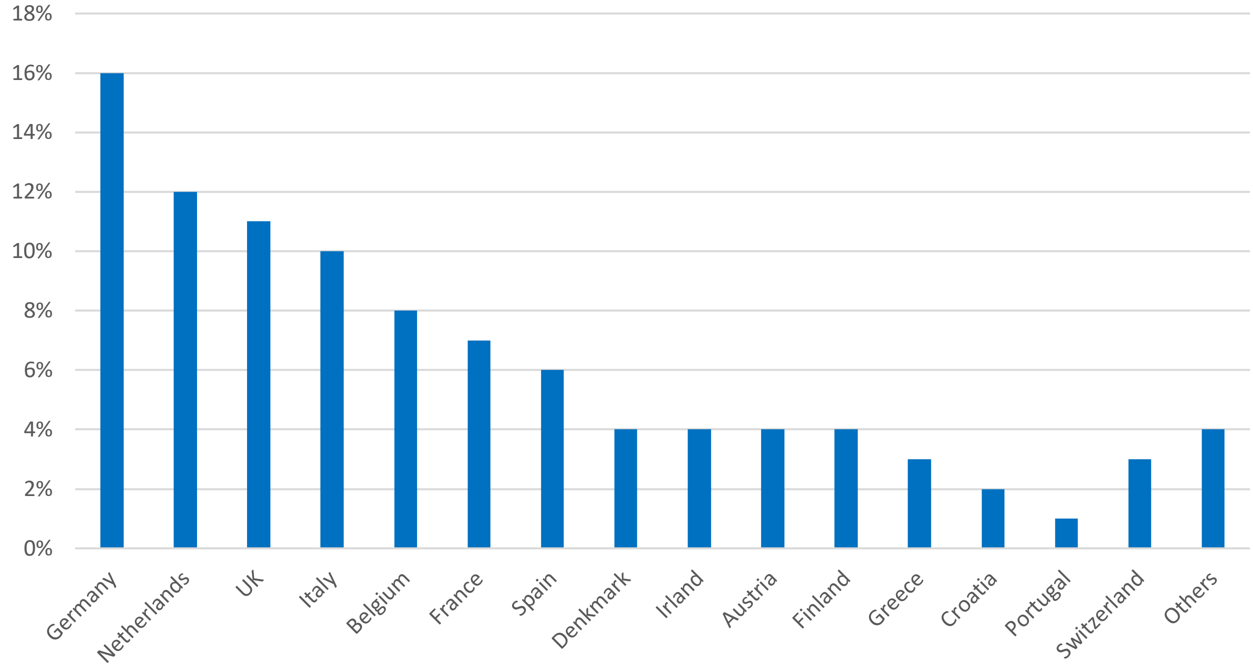

Figure 4 - Distribution of EC projects among EU Member States and Switzerland. In the graph "others" refers to Bosnia, Bulgaria, Cyprus, Estonia, Hungary, Luxembourg, Malta, Poland, Romania, Slovakia, Slovenia and Sweden;

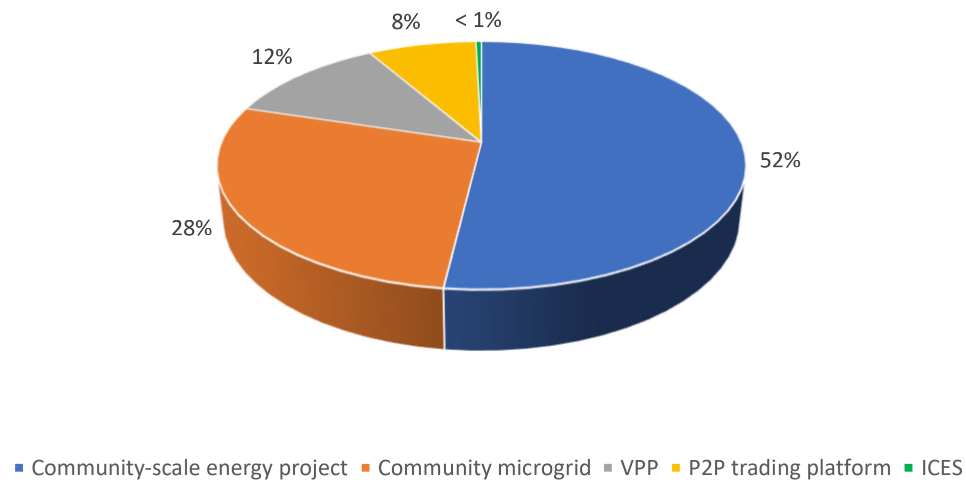

Figure 5 - Distribution of EC projects according to mentioned categories;

Looking at the distribution of the projects among the 5 different possible declinations of the Energy Community concept (shown in Figure 5), there is a clear prevalence of community-scale energy projects. These projects are more widely spread than other categories as they are easier to implement and generally do not face any legislative obstacles. In fact, the legal form that these projects usually assume is the cooperative one or an equivalent form, depending on the legislation of the country and the objectives that the community has set for itself (association, social enterprise, etc.). This form of EC is based on the involvement of citizens, who collectively decide to invest in the purchase and installation of energy production systems, thus becoming owners and members of the community that is created.

The second most common type of energy community is the community microgrid, in which communities self-produce local energy and directly manage the connections between their members. These initiatives are divided into two main groups, which differ according to the reason for their formation: communities born out of necessity, in places not well connected to the grid and to centralised energy production facilities (mountainous places or islands), and communities born for research purposes in order to optimise consumption in a limited environment.

It is also interesting to note that forms of 'virtual' aggregation, referring to VPPs and P2P trading platforms, together account for around 20% of the total number of projects mapped, with growing interest in recent years, reflecting the considerable interest on the subject. The "virtual" aggregation is indeed the configuration requiring no interventions to set up dedicated infrastructure to operate as they rely on public network for energy exchanges. It translates in lower costs connected to projects initialization for internal members.

Integrated community energy systems account for less than 1% of mapped cases, highlighting a scarce diffusion of such projects and mainly connected to research purposes. They require a complex and integrated resource management at local level, beside a consistent involvement of the whole community for which further cases are expected to raise as the awareness regarding community-based projects will be diffused among citizens.

2.4 EC in Italy

In Italy, there are already many energy communities and cooperatives located mainly in the northern part of the peninsula.
In the following paragraphs we will present some examples of prototype energy communities.

2.4.1 EC Magliano Alpi – Energy City Hall

The Municipality of Magliano Alpi, careful to the new energy models, wanted to make concrete act its adherence to the Manifesto of Energy Communities for an active centrality of the Citizen in the new energy market, promoted by the Energy Center of the Politecnico di Torino, giving birth to the first energy community in northern Italy, registered as an association with the Revenue Agency under the name of Renewable Energy Community Energy City Hall, with the Mayor as referent.
The energy community is developed around a 20 kW solar photovoltaic system, installed on the roof of the City Hall. Connected to the City Hall's POD, the system is aimed at ensuring the self-sufficiency of the building itself, the library, the gymnasium, and the municipal schools, and to exchange surplus energy with 5 participating households in order to meet about 40 percent of electricity consumption, as well as also powering an electric car charging station, free for REC members.
The Municipality has also purchased smart meters that, connected to all PODs participating in the REC, monitor and record the consumption of each utility and, along with this, the Energy4Com management platform is being used for the analysis of production and consumption energy flows and the management of all energy services.

The municipality is also grouping together a "GOC" (Community Operational Group) aimed at creating a "short supply chain of technicians, designers, installers and maintenance workers" with the goal of aggregating skills in the area to create development and jobs starting with the Community Energy.

2.4.2 ACEA Pinerolese

In Piedmont, the Pinerolo Energia Consortium (CPE), together with Politecnico di Torino and ACEA, is laying the groundwork for creating an energy community among several municipalities in the metropolitan city of Turin that, already involved in the "Oil Free Zone Sustainable Territory" project, have reduced energy production from fossil fuels, bringing their energy self-production capacity to 42 percent.

The goal of the project is to aim for 100 percent. The starting nucleus of the future Energy Community is made up of public and private users and in particular the municipalities of Cantalupa, Frossasco, Roletto, San Pietro Val Lemina, Scalenghe and Vigone with their respective citizens and 5 member companies of the CPE Consortium including Acea Pinerolese Industriale (API) S.p.A.

Different categories of actors (consumers, prosumers, producers), users (companies, municipal and residential public users) and renewable and non-renewable energy production technologies will also be involved. There are 162 public and private facilities planned to meet local energy needs for a renewable electricity production of about 16.9 GWh/year.

This contribution will come from the 450-kW hydroelectric plant in Inverso Pinasca and a biogas plant, generated by the treatment of organic waste, capable of producing about 80 percent of the community's energy needs by generating about 10 million cubic meters of biogas per year, from which about 17.1 GWh/year of electricity will be produced.

144 photovoltaic systems of 3 kW each, distributed among private utilities, to cover 3% of the needs along with an additional 13 publicly and privately owned with power ranging from 8.4 kW to 62 kW.

These are joined by an additional 113 kW photovoltaic plant, owned by API, and capable of producing about 114 MWh/year.

On the thermal front, the biogas plant, which is the only thermal prosumer, is capable of producing 18.8 GWh/year of thermal energy, distributing the share between the district heating network and its company's locations.

The thermal energy demand met by renewable energy varies, depending on the input of private users' boilers' contribution to the grid, from 10 to 24 percent.

The institutional form envisaged at the start-up stage is that of a "Temporary Purpose Association" to be later transformed into a cooperative.

In the context of the Oil Free Zone Sustainable Territory are also being implemented (within the terms of Law 8/2020): a Renewable Energy Community (REC) in the municipality of Villar Pellice from a photovoltaic plant, involving some municipal utilities and the company Crumière; one (photovoltaic source) in the municipality of Scalenghe involving some municipal utilities and some private utilities; beyond the terms of art. 42bis of Law 8/2020 but in view of the REDII conversion law, another energy community is planned in the municipality of Scalenghe, with primary source biogas from animal manure from a farm.

The intention then is to federate the energy communities into a Community of Communities comprising the Pinerolese Community.

2.4.3 GECO (Green Energy Community)

The GECO (Green Energy COmmunity) project, launched in September 2019, will lead to the creation of Emilia-Romagna's first virtual energy community by 2023, in the Pilastro and Roveri districts, using the existing grid in areas where there is currently 430 MWh of electricity consumption per year. The center of the community citizens and companies that will play an active role in the process of creation, production, distribution and consumption of energy.

The development area includes a residential area of 7,500 inhabitants, including 1,400 in housing social housing, a commercial zone of 200,000 sq. m. that houses an agribusiness park, two shopping centers, and an industrial area of more than 1 million sq. m., where there are currently solar photovoltaics totaling 16 MW on the roofs of the Bologna Agribusiness Center-CAAB and the FICO Foundation, and solar plants totaling 2 MW in the Roveri industrial area.

Through GECO, 8 new renewable energy plants associated with storage systems will be built, turning businesses and citizens into prosumers. Specifically: a 200 kW plant for the CAAB/FICO agro-industrial center to be built on the parking canopy, a 20 kWe and 30 kWt biogas plant for organic waste disposal, a 100 kW solar photovoltaic plant on multiple social residential buildings under ACER management, and additional 200 kW of solar in the Pilastro shopping center and for nearby apartment buildings. As well as two installations, also solar with 200 kW each, on the roofs of the Fashion Research Institute, ZR Experience and neighboring businesses.

All this adds up to a total of 14 MW of new power generated by photovoltaic systems, which by 2023 will produce more than 15.4 million kWh/year, saving 120 MWh/year of energy and avoiding the emission of 58,000 tons of CO_2/year into the atmosphere.

The project, promoted thanks to the co-financing of the European EIT Climate-KIC fund, by the Agency for Energy and Sustainable Development, ENEA and the University of Bologna, with the participation of citizens, local associations and businesses in the area, such as the local Development Agency Pillar District Northeast and CAAB, is still in the development phase, and from the point of view of technological innovation involves the development of a platform for the analysis of energy flows (production, storage and consumption), useful for ensuring the flexibility of energy within communities. Accompanied by technologies that can identify the

optimal configuration of smart equipment and thus enable community members to monitor their own consumption and energy contribution in the community.
All this together with a blockchain system aimed at recording self-consumption of electricity.

2.4.4 Roseto Valfortore

The Renewable Energy Community (REC) project in the municipality of Roseto Valfortore, Apulia, is being carried out by Friendly Power, a company engaged in the promotion, development, implementation and management of Energy Communities.
In the Energy Community, traditional and innovative technologies for the production of energy from renewable sources will meet with products (smartmeter; nanogrid) and services (power cloud) specifically designed and implemented.
Composed of citizens, small and medium-sized enterprises (SMEs) and the municipality itself, it will be able to increase the share of renewable energy produced and/or consumed over time, with the goal of reaching 100 percent and more of the total.
Friendly Power realized and presented, together with the Municipality, the social, economic and financial feasibility study on February 28, 2020 in the headquarters of the Province Di Foggia.
The REC creation process consisted of 4 phases, each with the main purpose of increasing the share of self-consumed energy by all members of the Energy Community.
In light of the novelties contained within ARERA's Resolution 318/2020/R/eel, the result of the application of Law 8 of February 28, 2020, which converts into law Decree-Law No. 162 of December 30, 2019, Friendly Power integrated the work previously carried out by delving into the technical and economic characteristics of the different EC configurations envisaged by the regulator; evaluated the best corporate form; and drafted the Energy Community's Bylaws and Internal Operating Regulations.

The most important novelty of the new regulation, which allows the EC of Roseto to significantly shorten the time required to implement the 4 phases, is that the regulator enables a "one-to-many" self-consumption configuration: energy produced by one or more RES plants can be shared and self-consumed by several self-consumers, albeit in a virtual form and provided that they all subtend the same secondary cabin.

This allows us, compared to the previous model, to start immediately from phase 3, that of community facilities. The municipality, by approving bylaws and internal rules of operation, has made its appurtenances available to the REC with the aim of implementing photovoltaic installations on them.

So, citizens and SMEs can participate right away even if they do not have appurtenances suitable for photovoltaic installation.

In this first phase, the municipality has about 30 adhesions, mainly families but also pmi. Friendly Power, on the other hand, is working on drafting the REC's energy balance sheet and carbon footprint, so as to best size the installations and set targets for reducing pollutant emissions.

The use of tools such as the smart meter and nano-grid will be key to achieving the set targets. In addition, the REC, by choosing the "basic set-up," will not carry out the investment directly but will have it carried out by a specialized energy company.

However, thanks to the support and commitment of Ecomill crowdfunding, the company implementing the plants will be open to all interested investors in the country, while giving priority to small local investors. The presence of Ecomill crowdfunding is also important to ensure maximum transparency in the relationship between the company's management and small investors. Of course, part of the economic benefits will be used to remunerate the company's investment, and the remaining part will be divided among REC members or used to trigger a virtuous process of promoting renewable energy sources.

In fact, the members will be able to freely decide what to allocate the investment to between: combating energy poverty; events promoting the Energy Community to broaden the audience of participants; and contributions to members for the implementation of energy efficiency and energy-saving measures.

The Roseto Valfortore Energy Community project makes use of the realization of products (smartmeter, nanogrid) and services (powercloud) born from the synergy between the Friendly Power Company and the Company, of the same Group, Creta Energie Speciali, a spin-off of the University of Calabria. The smartmeter designed and produced is able to acquire and send, instantaneously, all electrical quantities (voltages, currents, active power, reactive power, active energy, reactive energy, power factor) allowing users to become aware of their consumption in real time. With this monitoring system, it is possible to calculate the power and energy produced and/or absorbed by the user's systems.

It also distinguishes between the power and energy input, absorbed, produced by any generation system (such as, for example, photovoltaic) and the total power absorbed by the loads. The frequency of acquisition of these quantities can be chosen by the user based on his needs.

The nanogrid, on the other hand, is capable of integrating together and managing several generation systems, mainly from renewable sources, realizing a polygeneration system, including storage systems. It is designed to connect to other nanogrids, even those that are not physically interconnected, and to share energy resources. It can also operate off grid.

It connects to the public grid through a dedicated inverter-based Power Electronic Interface (PEI). When the inverter connects and synchronizes with the AC grid, it is able to operate bidirectionally. It is also able to create a local grid if there is no public one yet.

In addition, nanogrids are able to interact with each other, being able to exchange power, either through a local micro-grid or through the distributor's micro-grid.

The ability of nanogrids to talk to each other and to the Transmission System Operator (distributor, aggregator, reseller) allows for integration through the PowerCloud, while at the same time recording the exchanges that take place between the three actors in an Energy Community: users consumers (consumer), producer/consumer users (prosumer), facilities.

3. Regulatory framework

When it comes to law and regulation, it is very important to have a clear understanding of the framework we are moving in. This is something crucial in running business in a strictly regulated market such as the energy sector, where players must comply with the constraints imposed by regulatory authorities in order to ensure the proper functioning of public grid. This requirement is affected by some implications today, which come with the increasing diffusion of distributed RES plants. Due to their unprogrammability, the integration of non-controllable generation poses challenges to ensure the reliability of the grid, e.g., the presence of back-up power to ensure power supply when RES is not available. Moreover, ad-hoc measures have been designed over the years, on one side to ensure fair competition among players, while on the other one to innovate the energy market by ensuring the right integration of novelties in terms of hardware, software, generation systems, technologies for remote monitoring, and so on and so forth.

3.1 European Union

Understanding how European legislators operate in establishing rules and regulations to promote the deployment of energy communities is an important starting point for assessing the progress within the energy transition process where Europe aims to play a leading role. What is needed is a legislation promoting rights and provisions to support the development of an enabling environment for the deployment of energy communities.

As mentioned in the introduction of the study (chapter 1.1), in 2019 European Union concluded the approval of the "*Clean Energy for All Europeans*" package [19] consisting in eight Directives regarding different themes including: energy performance in buildings, energy efficiency, renewable energy, electricity market. These measures aim to put in place an appropriate legal frameworks to enable the energy transition and give citizens a leading role in the energy sector. The directives should be followed by national laws on the respective topics. The deadline for the transposition of the directives by the EU member states, and consequently for the drafting of national legislation, is June 2021. Among the various topics of interest, two of the CEP's directives put the lights on EC and CSC:

- *Renewable Energy Directive* (RED II) [20], providing definitions of *Collective Self Consumption* (CSC) and *Renewable Energy Community* (REC);
- *Electricity Market Directive* (EMD II) [21], defining *Citizen Energy Community* (CEC);

With the introduction of new measures and related definitions, the EU formally recognises for the first time "*renewable self-consumers*" and "*active customers*" as entities entitled to produce, store and consume electricity from renewable sources, but also to carry out activities beyond self-consumption, such as participation in flexibility or energy efficiency programs. In this way, electricity, produced individually or collectively, can be fed into the grids receiving a remuneration reflecting the market value, as long as this role is not their primary commercial or professional activity. The last principle is very important because it highlights the underlying aim of the configurations defined by the two directives which is to create benefits for the final consumer, both socially and economically. Thus, profit-oriented companies operating on the energy market are excluded from taking part in these bundle of activities.

CSC is addressed in article 21 of the REDII. The REDII defines "renewables self-consumers" as well as "jointly acting renewables self-consumers" as follows:

- *Renewables self-consumer*: "a final customer [...] who generates renewable electricity for its own consumption, and who may store or sell self-generated renewable electricity, provided that, for a non-household renewables self-consumer, those activities do not constitute its primary commercial or professional activity".
- *Jointly acting renewables self-consumers*: a group of at least two cooperating "renewables self- consumers [...] who are located in the same building or multi-apartment block";

Today some Member States already allow CSC on building scale, where inhabitants of one multi-apartment buildings share produced renewable electricity and connected installations such as a storage system. According to the REDII, besides electricity generation, renewables self-consumers should be able to exploit electricity storage systems without additional charges, including network ones. The self-consumer's installation may be owned or managed by a third party according to the consumer's instructions. For electricity fed into the grid, self-consumers shall be granted non-discriminatory access to relevant existing support schemes as well as to all electricity market segments.

In terms of scale, when collective self-consumption goes beyond the scope of a single building or apartment block, we are dealing with an energy community. As previously mentioned, CEP provides two definitions: REC in RED II, and CEC in EMD II. They are framed as a non-commercial type of market actor, which represents an important principle that MS's must ensure to create a levelled market where it is possible to operate without discrimination.

Table 2 provides an overview of the definition, actors, purpose and potential fields of activity of the two types of energy communities.

Renewable Energy Community (art. 2.16 RED II)	Citizen Energy Community (art. 2.11 EMD II)
Legal entity: a) based on open and voluntary participation, is autonomous, and is effectively controlled by shareholders or members that are located in the proximity of the renewable energy projects that are owned and developed by that legal entity; b) the shareholders or members of which are natural persons, SMEs or local authorities, including municipalities; c) the primary purpose of which is to provide environmental, economic or social community benefits for its shareholders or members or for the local areas where it operates, rather than financial profits;	Legal entity: a) based on voluntary and open participation and is effectively controlled by members or shareholders that are natural persons, local authorities, including municipalities, or small enterprises; b) has for its primary purpose to provide environmental, economic or social community benefits to its members or shareholders or to the local areas where it operates rather than to generate financial profits; c) may engage in generation, including from renewable sources, distribution, supply, consumption, aggregation, energy storage, energy efficiency

Moreover, it shall be entitled to produce, consume, store and sell renewable energy, including through renewables power purchase agreements.	services or charging services for electric vehicles or provide other energy services to its members or shareholders.

Table 2 - REC and CEC definitions according to RED II and EMD II directives

Reading the two definitions, we can highlights some major commonalties:

- they require to constitute a legal entity representing the community;
- they must be based on open and voluntary participation;
- focus is put on environmental, economic and social benefits rather than profit;
- governance is exerted by shareholders;
- must be collective initiatives;

According to the EMDII, "Citizen energy communities constitute a new type of entity due to their membership structure, governance requirements and purpose" where the purpose is framed around the provision of services/benefits for members or the local community. REC definition follow the same logic, highlighting the emphasis given by legislator on a specific way to organize an activity, rather the activity itself. However, both definitions include the acknowledgment of some activities that an EC could engage in.

To conclude the comparison, the major differences between the two definitions are presented in Table 3.

Renewable Energy Community (RED II)	Citizen Energy Community (EMD II)
- Proximity constrain (to be defined by national legislations); - Large companies are excluded from membership;	- No geographic constrain; - Medium or large companies excluded from effective control; - Power vector: electricity;

- Power vectors: electricity, heat; - Open to all types of RES;	- No constrains in terms of energy source (not necessarily RES);

Table 3 - Differences between REC and CEC definitions;

It is important to mention that these two types of organizational formats do not exclude additional alternatives defined on national level. While the REDII leaves this open, the EMDII explicitly states that "the definition of Citizen Energy Communities does not prevent the existence of other citizen initiatives such as those stemming from private law agreements." Therefore, if Member States choose to do so, they can allow market actors not foreseen in the directive to establish, own and manage local energy systems. Indeed, this is also defined for industrial and commercial enterprises under Article 38 of the EMDII on closed distribution systems.

Among the activities an EC can engage in, there is possibility to get access to energy markets without discrimination as a stand-alone seller or through "*aggregation*". The activity is defined in Article 2 of EMD II Directive as "a function taken by a natural or legal person that combines multiple customer
loads or generated electricity for sale, for purchase or auction in any electricity market". In RED II the activity is not defined but it refers to the figure of the "aggregator", thus meaning the exertion of aggregation activity.
Another important point is on the possibility for ECs to directly own and managing distribution networks. While the right to manage them is specifically included as optional for CECs in EMD II, the REDII only states that "renewable energy communities are not subject to discriminatory treatment with regard to their activities, rights and obligations as final customers, producers, suppliers, distribution system operators, or as other market participants". This guideline is included among the ones Member States shall take into consideration in defining the enabling framework aimed to foster integration and diffusion for ECs, giving in this way room for adjustments and interpretations to MSs.

3.1.1 Implications on public grid

With the raise of distributed generation, the most urgent challenge comes from integrating renewable energies into electricity grids, particularly at distribution level, where majority of these sources are connected. The overall costs of the system need to be shared by all grid users, while achieving a balance to pursue the two general and potentially conflicting principles of sustainability and affordability. Sustainable, because incentivising active consumers and renewable self-consumers increases the share of renewables in the EU's energy mix and contributes to the decarbonisation targets. Affordable, because most grid costs in Europe are still shared among all system users and paid in the form of grid tariffs to ensure revenues for grid operators.

Large shares of renewables, including electricity produced by self-consumers, are connected in medium and low voltage and integrated by the distribution system operator (DSO) into the grids. Therefore, EU has assigned new roles and responsibilities to DSOs which, in their function as regulated monopoly entities, will become "neutral market facilitators" and will have to carry out more active management of the system. The presence of active consumers brings some implications for DSOs, which should incentivise the further development of smart, flexible and digitalised grids, a crucial prerequisite for the connection and integration of CSC systems and EC. The new scenario will be characterized by the need for flexibility for load shifting and matching between generation and demand, access to storage facilities, congestion management rules, data exchange and management models, and further deployment of smart meters for data collection. Better cooperation between transmission system operators (TSOs) and DSOs is needed as well, and their interaction with all market players to provide information and technical support.

An increasing number of consumers will now enhance their energy independence and consequently contribute less to the overall costs of the system, while in most cases remaining connected to the grid for periods when there is no sun or wind. “Passive” consumers or those without access to self-consumption from renewables will have to bear a bigger share of the system cost and may face increasing energy bills. The new European directives, therefore, recognise and address the need to balance this conflict of interest with certain provisions:

- Network charges must reflect real costs, contribute to the allocation of overall system costs and separately account for electricity consumed by the grid and electricity fed into the grid, gradually phasing out 'net-metering' schemes by 2023, to ensure that self-consumers pay the full cost of the grid usage service, without having their costs in charge to all other users [22];
- Principles should be established for network charges and tariffs, e.g., for connecting consumers to electricity grids, whereby citizens should not be discouraged from becoming self-consumers. Distribution tariffs can also be differentiated according to the consumption or generation profiles of users;
- Active customers are financially responsible for the imbalances they cause in the electricity system, but they can delegate their balancing responsibility to market operators offering such services, e.g., aggregators. As regards demand-response mechanisms, consumers have to pay compensation to other market players, or their balancing party, who are directly affected by their demand/response activity [23];

Many of the new provisions are kept at high level without deepening in details, as the cost allocation and financing of network access and use differs widely across EU. Overall, the EU's willingness to balance between the needs of users and those of the electricity system is evident, and MSs have to reflect this through implementation in national legislation.

3.2 Italy

In this section, the evolving National framework around self-consumption and energy communities is presented. Firstly, an historical picture about the previously-allowed configuration is provided, followed by the analysis of the EU directives transposition process going on nowadays.

3.2.1 Legislation prior to European directives

ARERA (Autorità di Regolazione per Energia Reti e Ambiente) is the Italian authority in charge of regulating and monitoring energy markets and the national grid. Over the years, its duty was to provide legislative measures in order to drive the innovation of the electric market with the aim to follow the technological and environmental trends. An important distinction within the legislation has been made between physical and virtual configurations, theme which is currently under the spotlights among EU MSs which has to decide the kind of approach to follow in enabling the new systems object of the analysis.

Regarding *physical configuration*, legislative framework was mainly defined by the two following deliberations:

- 578/2013/R/eel [24], published by ARERA on 12th December 2013, which defined the methods for regulating services related to connection, measurement, transmission, distribution, dispatching and sales in the case of plant configurations belonging to the category of simple production and consumption systems (SSPC – Sistemi Semplici di Produzione e Consumo), including efficient user systems (SEU – Sistemi Efficienti di Utenza);

- 539/2015/R/eel [25], published by ARERA on 12th December 2015, which defined the regulation of the services related to connection, measurement, transmission, distribution, dispatching and sales in the case of closed distribution systems (SDC – Sistemi di Distribuzione Chiusi);

<table>
<tr><th colspan="2">Simple Production and Consumption Systems
(SSPC – Sistemi Semplici di Produzione e Consumo)</th><th>Close Distribution Systems
(SDC – Sistemi di Distribuzione Chiusi)</th></tr>
<tr><td rowspan="2">SAP – Sistemi di Auto-produzione</td><td>Consorzi e Cooperative storiche con rete propria</td><td rowspan="3">RIU – Reti Interne di Utenza</td></tr>
<tr><td>ASAP - Altri Sistemi di Auto-Produzione</td></tr>
<tr><td colspan="2">SEU – Sistemi Efficienti di Utenza</td></tr>
<tr><td colspan="2">ASE – Altri Sistemi Esistenti</td><td rowspan="2">ASDC – Altri Sistemi di Distribuzione Chiusi</td></tr>
<tr><td>SEESEU – Sistemi Esistenti Equivalenti ai Sistemi Efficienti di Utenza</td><td>SEESEU A/B/C/D</td></tr>
</table>

Table 4 - In the table, the recognized physical configurations are reported. The highlighted boxes refer to the configurations still allowed for new implementations. Information about each definition are not reported to avoid too many details which go beyond the scope of the analysis. If needed, they are available in the two directives by ARERA;

A *Close Distribution System* is defined as a private electricity grid which distributes electricity within a geographically limited area like an industrial, commercial or shared services site. It does not supply civil clients, except for family units hired by the owner of the distribution system or linked to him by a similar constraint. They must have a responsible subject who acts as the unique manager of the network, who is considered as a Distribution System Operator (DSO) except for having no constraints set by the Italian Energy Authority (ARERA) in applying connection, transport and measurement fees to the internal customers. ASDC refer to systems not complaining with RIU definition but still classified as SDC.

Simple Production and Consumption Systems have the presence of both producers and consumers. They are defined as configurations characterized by the set of electrical systems, which are connected directly or indirectly to the public grid, where the transport and delivery of electricity to the consumption units that constitute them it does not qualify as a transmission and/or distribution activity, but as an energy self-supply activity attributable to a 1: 1 scheme. This is related to the concept of individual self-consumption, while collective forms were still not recognized. On the contrary of heat supply, any transfer or sale to third parties of any form of electricity was indeed forbidden in all contracts regarding electricity supply for residential and SMEs loads which could lead to the diffusion of CSC or EC models. According to this, "hidden clients", i.e. final customers to who it is attributed a unit of consumption sharing the point of common coupling (POD) with other ones, were contrasted by national authorities through penalties and denunciation by the judiciary authorities.

For what concerns *virtual configuration*, ARERA defined the framework through the following directives:

- 393/2015/R/eel [25], where for the first time in the Italian regulations the authority refers to the concepts of the "aggregator" and aggregation. The latter regards the possibility to group energetic units to give birth to complex energetic compounds which for relevance or size would be such to reproduce the performance of larger units. According to the documents, such systems could be enabled to participate – as a whole – also to more remunerative markets, such as the one for ancillary services;
- DCO 298/2016/R/eel [26], where the authority proposed a first series of guidelines concerning the interventions and the modifications to be performed

in order to realize the promoted electric dispatching reform (RDE – Riforma del Dispacciamento Elettrico) with the aim to increase the number of units that can offer ancillary services;

- 300/2017/R/eel [27], through which a set of pilot projects have been launched in partnership with the Italian TSO Terna S.p.A. with the aim of experimenting the participation to the dispatching services market (MSD – Mercato dei Servizi di Dispacciamento) even for distributed generation systems. The concept of aggregate virtual unit (UVA – Unità Virtuali Abilitate) has been introduced and the new role for the aggregator has been defined;

Initially, four different definitions of UVA were provided. As in the case of physical aggregation, further details are not provided but are available within the directives:

- **UVAC** (Unità Virtuali Abilitate di Consumo);
- **UVAP** (Unità Virtuali Abilitate di Produzione);
- **UVAM** (Unità Virtuali Abilitate Miste);
- **UVAN** (Unità Virtuali Abilitate Nodali);

Starting from November 2019, ARERA decided to maintain only UVAM definition, indicating aggregations of consumption and/or production units that are merged to allow participation in the dispatching market. This is done thanks to the aggregator, known also as BSP (Balance Service Provider), which can allow end customers to modulate their electrical loads and in this way to participate in the dispatching market. By aggregating production or consumption units, in fact, it is possible to handle sufficient volumes to participate in the MSD via an auction mechanism through which the national TSO, Terna S.p.A., secures a certain capacity available to provide dispatching services. The minimum modulation capacity threshold of the UVAM is 1 MW in order to qualify for participation on the dedicated market.

3.2.2 Transposition Process

Year 2020 has been crucial in terms of evolving legislation to transpose EU directives into the national regulatory framework. In figure 6 the main acts are reported.

Figure 6 - Timeline of European and National legislative acts.
(*)MiSE stands for "Ministero dello Sviluppo Economico", the Italian Ministry of Economic Development.

Italy started the transposition process on 30th December 2019 with the publication of Decree Law 162/2019 [28], named "*Milleproroghe*", containing initial provisions for setting the framework for collective forms of self-consumption and energy communities defined by EU RED II Directive. The Decree was converted into law on 28th February 2020 through Law 8/2020. Within the Decree acting on various sectors, the article 42 is dedicated to self-consumption from renewable energy sources. In particular, for the first time within national legislation reference is made to "jointly acting renewables self-consumers" and "renewable energy community".

Collective Self-Consumption is enabled for natural persons or commercial actors, for whom generation and energy exchange is not the core business, and that are located in the same building or condominium. The production plants must be based on RES and placed in the same building of the CSC scheme, with a power threshold of 200 kW each. Eligible plants came into operation after the date of entry into force of the conversion law of the decree, 1st March 2020, and within sixty days following the date of entry into force of the measure definitely transposing the EU directive, expected by

June 2021. Producers may possibly be third parties, including those who carry out the activity of production as their main activity, with the obligation to operate on behalf of the final customers. They are not part of the group of self-consumers but the electricity they feed-in is relevant for the identification of self-consumed energy.

Renewable Energy Communities involves natural persons, small and medium enterprises, local/regional authorities (e.g. municipal administrations), and private companies. This shall include low-income and vulnerable residents. In fact, the main objective of a REC is, according to the EU guidelines, to provide environmental, economic, or social benefits to its shareholders/members or to the local area, rather than financial profits. As in the case of CSC, energy generation, supply etc. must not be the main commercial activity of these actors. Generation plants, like community members, must be located downward the same medium-to-low voltage transformation station and the 200 kW power cap for single plant apply.

Time frame for coming into operation is the same as CSC scheme, and same logic for third-party producers applies as well. Among other activities such as produce, share and store electricity, a REC can carry out aggregation activities and act as a balancing service provider.

For both CSC and REC, a virtual configuration approach is used. The configurations must rely on the existing grid infrastructure, without the possibility to set and run private networks. They can exchange electricity with the public low-voltage grid and self-consumption is calculated on hourly basis as the minimum of aggregate production, measured as energy injected into the grid, and aggregate consumption, measured as withdrawn energy from public grid.

It is important to highlight that with "Milleproroghe" Decree-Law, Italian authorities wanted to anticipate the deadline for transposing EU Directive, June 2021, with the aim to have a trial phase where experimental projects are implemented in partnership among proposing parties, e.g., private companies or municipalities, Terna S.p.A., and

RSE S.p.A.[2] in order to investigate real potential benefits of energy communities, better assess the economics associated with such implementations and consequentially define proper supporting schemes. The study has been undertaken by RSE through a call for tender where partner players have been selected [29]. Despite selected parties have been published in February 2020, pilot projects are still at embryonic stage due to uncertainty connected to the evolving legislative framework and legal barriers which in some cases constrain implementations[3].

After the drafting of "Milleproroghe" Decree-Law, ARERA published on 1st April 2020 the consultation document *112/2020/R/EEL* [30] which sets out the Authority's guidelines for regulating the economic aspects of electricity consumed on a collective basis or shared within renewable energy communities. Following the publication, the Authority collected observations and proposals from interested parties operating in the energy industry.

The final version of the consultation document was published on 4th August 2020, *318/2020/R/EEL* [31], for which the main provisions added to the initial framework set by "Milleproroghe" Decree-Law are reported in the following:

- For RECs, they must constitute a legal entity (e.g., association, third-sector organization, cooperative, benefit cooperative, consortium, public-private partnership, non-profit organization);

[2] Ricerca Servizi Energetici S.p.A. is a joint-stock company controlled by GSE S.p.A. (Gestore dei Servizi Energetici S.a.A.), for the development of research activities in the electro-energy sector, with particular reference to national strategic projects

[3] Evidence received by directly contacting TCVVV (Teleriscaldamento Coogenerazione Valtellina Valchiavenna Valcamonica), private company whose core business is realizing and operating district heating infrastructures. In particular, the legal constrain affecting the project is the fact that their customers are connected via different secondary transformation stations, so not in compliance with REC provisions given so far.

- Definition of the "referent" role as responsible for relations with the GSE[4] for setting up the configuration and requesting the access to the valorization of shared electricity and incentives. In case of CSC he is either the legal representative of the building or condominium, or the producer operating one or more production facilities belonging to the configuration (as previously indicated, he may not be part of the configuration). In the case of a REC, the referent is the community itself, as a legal entity;
- Clarification regarding the role of "producer", defined as a natural or legal person who produces electricity independently of ownership of the production facility. He is the holder of the generation plant and of the authorizations to build and operate it. As previously described, it gives the possibility for third-parties to manage, monitor and maintain plants on behalf of internal members;
- Definition of the value for tariff components subject to restitution from GSE.

They differ between the two configurations as reported in table 5;

Configuration	Reimbursement, for the share of shared energy, of the variable parts related to: - transmission (TRASE)[5] ; - distribution (BTAU)[6];	Restitution reflecting the reduction in grid losses associated with the local consumption of energy where it is produced, equal to: - in the case of plants connected to low voltage, 2.6% of the hourly zonal price[7] for the share of shared energy; - in the case of plants connected to medium voltage, 1.2% of the hourly zonal price for the portion of energy shared;

[4] GSE is in charge of paying incentives and returning tariff components which are not applicable to the energy shared within the two configurations because it is instantaneously self-consumed on the same portion of the low-voltage network.
[5] In 2020 equal to 0,761 c€/kWh
[6] In 2020 equal to 0,061 c€/kWh
[7] In 2019 equal, on average, to 5,2 c€/kWh

CSC	✓	✓
REC	✓	✗ *

Table 5 - Tariff components reimbursed from GSE

(*) ARERA specifies that in the case of renewable energy communities, it is not possible to recognize the repayment of components related to the additional avoided grid losses, since in any case the electricity shared within the community exploits public distribution grids.

To conclude the pilot phase within the process towards the full transposition of EU RED II, after receiving technical provisions by the competent regulator, the Italian Ministry of Development published on 16^{th} September 2020 the Implementing Decree [28] regarding the identification of incentive tariff for the remuneration of renewable energy installations included in configurations for collective self-consumption from renewable sources and in renewable energy communities. The electricity produced by each of the RES plant being part of the configurations and which is shared is entitled, for a period of 20 years, to an incentive tariff in the form of a feed-in premium equal to:

- 100 €/MWh if the production plant is part of a configuration of collective self-consumption from renewable sources;
- 110 €/MWh if the plant is part of a renewable energy community;

The entire energy produced and fed into the grid remains at the disposal of the configuration referent, with the right to sell it to the GSE.

The defined incentive measure is alternative to the existing “Scambio sul Posto” remuneration for RES plants entered into operation between 1^{st} March 2020 and sixty days after the date of entry into force of the MiSE Implementing Decree (17^{th} September 2020). Plant owners can withdraw from the convention in order to switch to CSC or REC configurations, thus accessing the ad-hoc incentive defined for them.

Moreover, there are further economic benefits connected to RES plants installations in the form of tax deduction which are the following:

- Superbonus 110%

  Defined within Decree-Law 34/2020 [28], published on 19th May 2020, with the aim of fostering economic recovery in the context of the current pandemic crisis. If the production system belonging to the configuration is a PV plant which is installed associated with specific energy efficiency measures[8], it consists in a 110% tax deduction of the amount of expenses corresponding to the first 20 kW of installed power[9]. This incentive cannot be combined with the one regarding shared energy defined by MiSE. The shared electricity underlying the share of power having access to the Superbonus is subject only to the contribution provided by ARERA regulation. Defined deduction applies also to storage system[10] or EV charging station installations[11];
- Bonus Casa 50%

  For RES installations, tax deduction of an amount equal to 50% of the associated CAPEX, within the overall spending limit of €96,000, is established by 1986 "TUIC" Act [32]. In case of access to Superbonus 110%, the present deduction applies on the exceeding part of installed power beyond 20 kW. On the contrary of Superbonus 110%, the shared energy covered by this measure is eligible also for the direct incentives provided by MiSE (100 or 110 €/MWh), beside the ones provided by ARERA;

Lastly, on November 2021, with the publication in the Official Gazette of the legislative decree 199/2021, the transposition process of the REDII Directive has been completed

[8] The eligible expenses must be covered by residents and incurred between 1 July 2020 and 31 December 2021. Superbonus 110% applies to all the measures contained in Decree-Law 63/2013, but only if they are carried out in conjunction with key measures, i.e. thermal insulation or replacement of winter air-conditioning.

[9] Expenditure cap of €48,000 with a limit of 2,400 €/kW

[10] Expenditure cap of €48,000 with a limit of 1,000 €/kWh

[11] No expenditure limit

and the Decree came into force on December 15. From the previous legislative acts some changes have been introduced. The main ones consist, with regard to energy communities, to an increase in the power limit of plants eligible for incentive mechanisms from 200 kW to 1 MW, as well as the possibility of accounting shared energy for PODs under the same primary cabin (instead of the previous limit to the secondary cabin).

3.3 Overview of Member States and Switzerland

By analysing the legislation state of advancement, the European picture presents an heterogeneous scenario in the process of transposition of EU directives in terms of technical details and timing. Despite not being an EU member, Switzerland has been included in the analysis to enlarge the scope of it and for the interesting framework put in place. For Europe as a whole, the state of definition in national legislation is more advanced on CSC and REC, defined in RED II Directive, than CEC. The deadlines for transposition are December 2020 and June 2021, respectively for EMD II and RED II. Therefore, this is an ongoing process for which the full picture will be defined during 2021 or even later, especially with Governments overwhelmed by the pandemic crisis and consequent economic crisis to face in this historical moment. As of today, the picture with the configurations recognise by law is the one presented in table 6. It is important to mention that legislation on energy communities often cannot clearly be attributed to either RECs or CECs. For instance, this is the case of Germany. However, the detailed country sections will show that the framework presents recognised forms of collective self-consumption somehow in line with EC definitions provided by European Commission. Belgium is a federal state for which details about every region are shown, thus representing an interesting case with different regulations within the same EU Member State. The case of Switzerland is a specific one as the EU definitions and regulations do not apply.

Member State		Collective Self-Consumption	Renewable Energy Community	Citizen Energy Community
Italy		✓	✓	✗
Austria		✓	✓	✓
Portugal		✓	✓	✗
France		✓	✓	✓
Spain		✓	✓	✗
Belgium	Wallonia	✓	✓	✗
Belgium	Flanders	✓	✓	✓
Belgium	Brussels	✓	✗	✗
Germany		✗	✗	✗

Table 6 - State of progress of EU directives transposition across selected Member States;

Hereafter, the regulatory framework for the analysed countries is presented more in detail. It is important to understand in which direction the measures aimed to introduce CSC and ECs are going across Europe and consequently how the future energy market will be shaped.

3.3.1 Austria

In the country, private and commercial CSC is allowed since 2017, when EIWOG [33] electricity act has been published by Austrian Government. The amendment enabled CSC within the same building, e.g., multi-apartment block or shopping mall, through the definition of the roles for all the actors involved and contractual relationships which should be established among them. Moreover, in the same year a supporting scheme for CSC projects on national level has been defined.

In September 2020, the Renewables Expansion Law (Erneuerbaren Ausbau Gesetz, Government of Austria) [34] has been published. The package amends a number of laws regarding energy field, including the mentioned EIWOG, to set a new framework for both RECs and CECs in line with EU directives, maintaining the existing CSC scheme defined in 2017. Regarding RECs, beside generate, store, and supply renewable energy they can operate as aggregators and offer energy services. They can be organized as cooperatives, associations, partnerships, corporations, association of housing owners or similar legal entities. An implemented REC can own and operate an electric grid, under the fulfillment of the same obligations as DSOs. The directive goes beyond the primarily electricity vector through the specific provision of subsidies defined for district heating grids in order to reach technology neutrality among different source of renewable energy. Similar rules apply for CECs.

The only major difference is about proximity constrain. While RECs have to be implemented within the same network area, either at LV or MV level, CECs can be established over the entire national territory, in compliance with EU definition in EMD

II. The latter configuration implies an additional criticality to be addressed, taking into account that members can be connected on different portions of national grid which could be owned by different DSOs. They are required to cooperate in metering activities, providing to the communities all the data needed to properly run activities, while in the case of RECs they deal with one single DSO.

3.3.2 Portugal

As of today, CSC and RECs are recognised by law. The RED II has been transposed in October 2019 through the publication of Decree Law 162/2019 [35] regarding the introduction of renewable energy self-consumption in collective forms and energy communities. The law adopts the major lines of the EU RED II in terms of membership, activities, additional services and the need to form a legal entity, while it does not include provisions about CEC and in general about EMD II. The recognised configurations can establish and operate their own grid in case of no access to the public network.

CSC or REC projects must register on a dedicated web portal of the Portuguese Directorate General of Energy and Geology (DGEG). To do this, they must name a representative entity which takes care of the application process and interfaces with competent authorities, after which the case is evaluated and the legal entity is constituted. The case-by-case evaluation is done to assess spatial limitation of the project and involved participants. The geographical constrain is based on the same voltage level, despite starting from January 1st 2021 DGEG has the flexibility to consider project-specific situations that are associated with different voltage levels. On one side, this can represent a good way to constitute additional projects, while on the other side it can create an issue of transparency leading to the difficulty of projects to assess their chances for receiving the recognition before submitting the application.

3.3.3 France

Individual and collective self-consumption has been introduced in 2016 through ordinance 2016-2019, which has been updated the next year with law 2017-227 [36] and decree 2017-676 [36]. CSC was allowed at building scale, then updated in 2019 within the transposition process of EU directives through law 2019-1147 [36] with the extension of physical distance between injection or consumption points at 2 km (respecting the threshold of 3 MW of cumulative power installed).

In the same year, EU RED II definition of REC has been included in French Energy Code [37], recently followed by CEC definition. This makes the French regulatory framework one of the most complete ones across European Union in terms of facilitating energy communities diffusion.

In line with regulatory frameworks from other MSs, project participants must constitute a legal entity for ECs, while France constitutes an exception for requiring a formal legal entity also for CSC. Moreover, RECs and CECs must rely on public grid, they are indeed not allowed to constitute and manage their own grid infrastructure.

3.3.4 Spain

In the Spanish picture, attention has been given more on self-consumption, rather than the concept of energy community. In particular, the framework has been defined by Royal Decree-Law 15/2018 [38] and Royal Decree 244/2019 [38], which set baseline provisions for administrative, economic and technical conditions for both individual self-consumption and collective forms organized by groups of apartments or industrial sites. CSC can rely either on private lines or public grid and it is subject to the following conditions:

- Involved members must be connected to the same low-voltage distribution grid;

- Production and consumption points cab be at a maximum distance of 500 m;
- Members located in the same cadastral area;

Moreover, within the compensation schemes a distinction is made between self-consumption forms entitled to feed energy surpluses into the grid and ones without this possibility.

Recently, in June 2020 the definition of renewable energy community in accordance with EU RED II has been introduced for the first time through Royal Decree 23/2020 [38], which provides only its general purpose and nature without deepening in practical details. By considering the expanded Spanish scheme for CSC, the current legislation can be considered as an hybrid model with an overlapping between the concepts of CSC and REC provided by EU. For this reason a need for clarification emerges. Thus, the development of a comprehensive framework for energy communities is currently under revision, beside other measures regarding tariffs for self-consumption and compensation schemes.

3.3.5 Belgium

Belgium is a federal state divided in three main regions with different legislative frameworks: Wallonia, Flanders and Brussels Capital Region. This makes the country a notably case of analysis given its internal heterogeneity. Details about each region are presented in the following.

In Wallonia, provisions for CSC were adopted in 2018 [39] within a process to promote energy consumption from renewables and facilitating their integration. One year later, in May 2019, RECs definition in line with RED II Directive has been introduced, framing them as legal entities through which members can share within a “local perimeter” their production and consumption of electricity from either RES or high-efficiency cogeneration. In addition to produce and consume, they can operate all the activities defined by EU directives, such as store and sell electricity, for the benefit of participants by using public or private grid.

Law defines "local perimeter" a grid segment where the connection points are located downstream of one or more medium-to-low voltage transformation stations. This opens different cases of local perimeters for which the definition refers to technically, socially, environmentally, and economically optimal section of the grid to promote local self-consumption. The perimeter is evaluated case-by-case by Wallonian Energy Commission and network operators.

In Flanders region, Flemish government has transposed EMD II and RED II directives in November 2020 [40]. Energy communities are entitled to run all the activities defined at European level, such as produce, consume, store and sell energy, offer flexibility services, aggregation, and electric vehicles charging services. The transposition of REC and CEC definition corresponds to EU directives, while criteria for participation based on technical and geographical proximity are under revision through a cost-benefit analysis which takes into account their impact on distribution networks. In addition, in some case RECs or CECs may be allowed to constitute and run their own network.

The legal framework adopt "active consumer" definition, opening possibilities for residents of multi apartment buildings to share local produced energy in line with CSC concept.

The Brussel Capital Region currently has no legislation regarding REC and CEC configurations. Until the transposition, the regulation authority allows energy community pilot projects with the involvement of the local DSO. Regarding self-consumption, collective forms are defined by law since 2018 [41] as legal entities formed by multiple subjects, either producers or consumers, whose meters are under the same MV/LV substation. In this case as for France, CSC requires a formal organization.

3.3.6 Germany

As previously mentioned, Germany has not yet undertaken the transposition process of EU directives with the correspondent definitions of CSC, RECs and CECs. Nevertheless, the country has a long tradition regarding self-consumption in residential buildings. It is allowed since 2000 through “Erneuerbare-Energien-Gesetz” (EEG), law which regulates surpluses injections into public grid and promotes diffusion of renewable energy sources through incentive schemes (feed-in tariff) to remunerate citizens who undertook the investment in green production technologies such as solar PV.

In 2017, “Mieterstrommodell” [42] has been introduced, opening the opportunity for the creation of collective forms of self-consumption in apartment blocks. Plant operator can sell the produced electricity to tenants in “direct proximity”, term which has created various interpretations leading to evaluation of different cases by regulatory authorities. The selling must be done using the internal grid of the building without relying on public one. The subject who manage the production plant, located within the perimeter of the building, is recognised by law as an electricity supplier. In the case of PV installation the cap is 100 kw. Moreover, in case of storage system installation the incentive is recognised on the base of the self-consumed electricity from it, and not on the bae of the entire stored energy.

3.3.7 Switzerland

Switzerland presents its own regulatory framework, as the country is not part of European Union. Given this independency, Swiss law has no obligation to comply with the transposition process going on across Member States, thus presenting different definitions around the concept of self-consumption.

A favorable framework for self-consumption in collective forms has been set through a new energy law (Energiegesetz [43]) adopted in 2016, followed one year later by an energy decree (Energieverordnung [43]). They are in force since 1st January 2018, date from which "Zusammenschluss zum Eigenverbrauch" (ZEV) are enabled, term which stands for self-consumption consortiums through which locally produced electricity can be consumed and shared among project participants or sold to the grid. They can be organized through either citizens-based initiatives or external energy service providers. The production plants and involved buildings must not have public area in between and must be connected under the same point of common coupling without using public grid for internal exchanges of electricity. From the point of view of the DSO, a ZEV is under the same meter and it is indeed considered as one final consumer. Beyond the main meter, participants can autonomously measure electricity consumptions to properly monitor and manage internal exchanges, with the possibility to rely on external service providers like ESCos.

In April 2019, updates to ZEV regulation have been approved such as internal pricing dynamics or allowing properties separated by public area, e.g., a railway, a river or road, to constitute consortiums.

4. The Energy Communities supply chain: the business models of the operators

This chapter aims to analyze the business models that can be adopted by operators. In particular, the analysis focuses on:

- The activities for the creation and management of a collective self-consumption and Energy Community configuration, i.e., the activities that can be carried out by third parties in order to create and manage collective self-consumption and Energy Community configurations;
- The business models adopted by "third parties" interested in contributing to the creation and management of collective self-consumption and Energy Community configurations, identified from the scope of activities managed;
- The breadth of supply, understood as the degree of "coverage" of current market supply with respect to the technologies and activities that fall within the scope of an Energy Community.

4.1 Activities for managing C.S.C/E.C.

The recent introduction of configurations of collective self-consumers of renewable energy and renewable energy communities in Italian legislation opens up new business opportunities for energy players.

As discussed above, the definition of the regulatory framework is currently in progress: the first experimental projects are being implemented to date, enabled by the current rules, having a transitional character and functional to the final transposition of the RED II Directive.

By virtue of this, discussions with operators reveal a multiplicity of business model articulations currently under consideration to promote such initiatives.

Within the chapter, the business models that can be adopted by so-called "third parties" that in various capacities can play a role in the creation and management of a configuration of collective self-consuming renewable energy communities are identified and analyzed, starting with the identification of the macro-activities that underlie their creation and management.

The point of view that is assumed for the analysis of business models is that of a third party, i.e., an entity that is not part of the configuration of collective self-consumers or energy community as a member, but instead promotes the creation of a new configuration (so-called "Energy Community Developer").

The activities that an Energy Community Developer can manage within its business model are many, as detailed below.

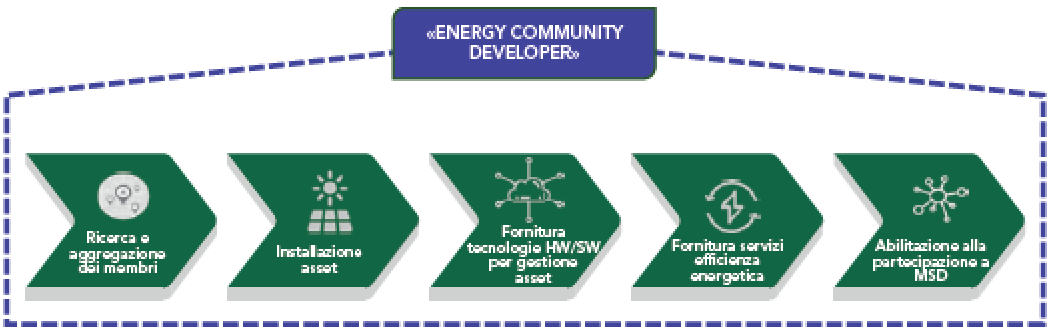

Figure 7 - Activities that an Energy Community Developer can manage within their business model. [9]

4.1.1 Member search and aggregation

The membership search and aggregation activity can be undertaken by a third party posing as the Energy Community "Developer," actively seeking out users interested in becoming members of an energy community or collective self-consumer group.

Alternatively, energy users could spontaneously decide to join with the intention of installing a renewable generation plant and sharing the energy produced. In this case, the third party would not be responsible for searching for community members, but would be approached by them to handle one or more of the subsequent activities for establishing and managing the initiative.

The member search activity requires the Energy Community Developer (in case it has a role) to make a significant outreach and information effort to energy users who are potential members of the configuration, to raise their awareness of the energy issue and the economic and environmental benefits that can be obtained by deciding to participate in the initiative.

Aggregation of members also includes identifying and contacting users who already own renewable generation facilities that came into operation after March 1, 2020, and who may be interested in making their facilities available to the community, while retaining ownership, in order to maximize the energy shared by the facility (with other entities) and increase the revenues associated with the facility.

In order to establish a Renewable Energy Community, the geographic constraint imposed by the regulations must be taken into account: all withdrawal and feed-in points considered must be connected on medium/low-voltage networks underlying the same HV/MV substation. To verify that this constraint is met, the Energy Community Developer must contact the local DSO to request the necessary information regarding the PODs of the users who want to join the Energy Community.

Finally, the members of the configuration must identify their contact person, who will be responsible for dealing with the GSE:

- In the case of a group of collective Self-consumers, this role can be carried out by the condominium administrator or a third party, possibly the same promoter of the community activation (i.e., the Energy Community Developer).
- In the case of Energy Communities, the role of contact person is assigned to the community itself, as a constituted legal entity. The community developer must then assess the interest of members who want to join the configuration, to the establishment in a defined entity (such as an association, third sector entity,

cooperative ...). The members of the Renewable Energy Community must adopt bylaws, attesting to its nonprofit character.

4.1.2 Asset Installation

The asset supply activity first includes the selection and sizing of the renewable source generation plant to be installed to produce the energy for the benefit of the configuration. This activity needs to be carried out taking into account any generation technologies that are already in place and have come into operation from March 1, 2020 onward, which the owners have made available to help account for shared energy internally in the community.

This activity is imagined to necessarily be carried out with the support of "expert" individuals, as community members do not possess the required expertise to carry out this activity. In any case, the members will remain the owners of the facilities, i.e., they will have full availability of the facilities, although they do not necessarily own them.

Furthermore, the party responsible for the operation and management of the facilities is the "producer," as defined by ARERA Resolution 318/20 [31], i.e., the one who owns the electrical workshop and can operate the facility, again in the interest of the community.

An Energy Community Developer can reasonably play the role of a producer.

In addition to the generation plant, other facilities that may be offered by the Energy Community Developer at this stage include storage systems and electric vehicle charging stations, while measurement hardware or advanced measurement and implementation devices are imagined to be provided concurrently with the adoption of the relevant software platforms to which they are connected and are included in the next stage of the supply chain.

4.1.3 Supply of HW/SW technologies for asset management

Energy sharing among community members takes place according to a "virtual" mechanism, so the existing network is used and no additional hardware or software technology is strictly required to enable energy sharing and related metering.
The Energy Community Developer may already have these technologies available as proprietary or acquire them from a technology provider.
The benefits associated with adopting these HW/SW technologies are:

- more efficient and effective management of installed assets;
- "optimization" of shared energy metering.

More efficient management of installed assets refers to the ability to monitor data on the operation of facilities or on energy consumption by users and, based on this, implement energy efficiency actions that give rise to savings.
Secondly, more effective asset management is to be understood from the perspective of maximizing shared energy, applicable especially to charge and discharge storage cycles and possibly also to load shifting and peak shaving of consumption.
The "optimization" of shared energy accounting refers to the sharing of economic benefits among different members of the configuration. In particular, two different case histories are identified:
- In the case where the Energy Community Developer intends to adopt "energy" criteria for the sharing of economic benefits among the different members of the configuration, he could take advantage of the HW and SW management infrastructure he has installed, so as to have visibility over the energy flows within the community and be able to divide the revenues by timely estimating the amount of shared energy associated with individual utilities.
- Conversely, should the Developer not install the HW/SW management infrastructure, he could opt for a "non-energy" allocation criterion (e.g., millesimal allocation) to determine the number of incentives due to each member, the implementation of which would not require the aid of energy-type data collection systems.

4.1.4 Supply of energy efficiency services

The provision of energy efficiency services, like the provision of HW/SW technologies, is not strictly necessary for the operation of a collective self-consumption or energy community configuration; however, it has been identified by several players as a potential "add-on" offering as part of the development of these initiatives.

In fact, the Energy Community Developer can propose to the members of the configuration, directly or through their contact person, interventions aimed at the efficiency of their consumption, such as replacing fixtures, adopting efficient lighting systems, thermal insulation, and other interventions that allow to reduce the consumption of the members of the configuration.

To this end, the presence within the community of devices capable of monitoring energy flows and an energy monitoring and energy management platform allows a more accurate assessment of potentially implementable interventions and offers the possibility of "certifying" the savings that each efficiency intervention has generated.

The provision of energy efficiency services can be proposed concurrently with the creation of the configuration or as a subsequent step, once a "history" of energy flow data characterizing the configuration has been created. In addition, having at his disposal the consumption curves of individual users, the Energy Community Developer can also propose efficiency interventions aimed at individual users of the configuration who, for this activity, will act independently with respect to the configuration as a whole.

4.1.5 Enabling participation in the MSD

A further activity relates to the possible participation in the MSD, through the intervention of a Balance Service Provider, enabling the community to provide balancing services to the grid.

Under the current regulatory framework, in order to implement this activity, specific hardware monitoring devices (the UPMs) are required and a communication channel with Terna must be established. In addition, in a UVAM scenario with a multiplicity of underlying units, the presence of a software platform equipped with the Dispatching Management module for automated management of dispatch orders is expected.

In the current scenario, it is likely to imagine that the BSP is an entity that performs the same activity with other UVAMs that were already active prior to the introduction of the collective self-consumption and Energy Community configurations, which therefore already possesses the technological infrastructure necessary for enabling participation in the MSD and proposes to the community to join one of these existing aggregations or to create a UVAM from scratch with members of the configuration.

In a less likely scenario, the Energy Community Developer, having neither prior experience with the UVAM pilot project nor the intention to take advantage of collaboration with an existing BSP, decides to undertake this new activity on his own by taking advantage of the aggregation of Community users. In this case, he would be responsible for implementing the entire hardware and software infrastructure required for MSD enablement.

4.2 Business models

We identify 3 main articulations of the business model of Energy Community Developers, characterized first by different coverage of the activities previously outlined.

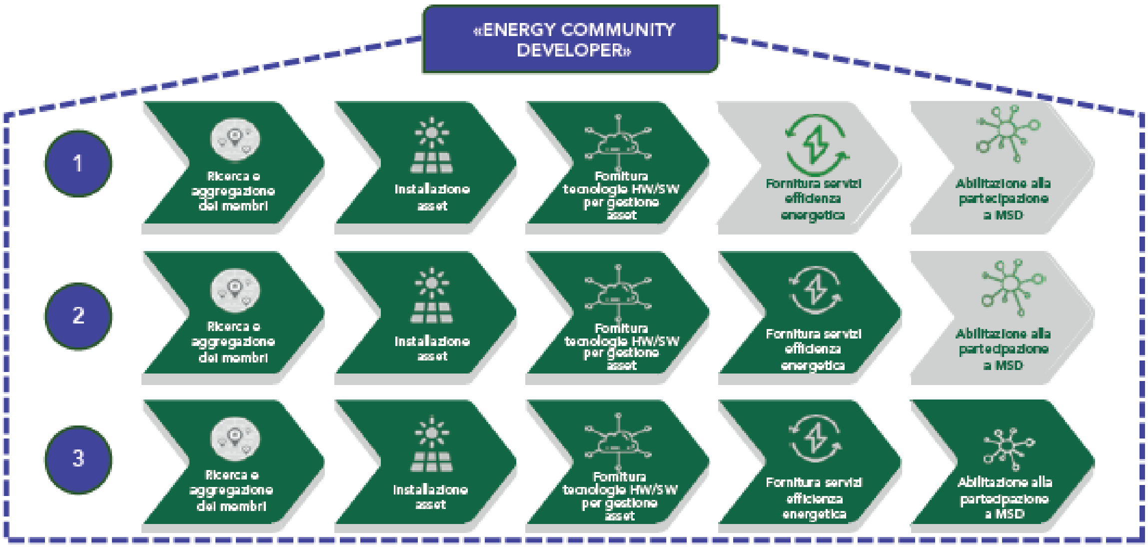

Figure 8 - Energy community developer [9]

All business models cover the activities of member research and aggregation, hardware and software technology supply.

Comparison with industry players shows that:

- "spontaneous" aggregation of members is unlikely. The "catalytic" role played by Energy Community Developers is also considered crucial.
- It is appropriate to provide for the installation of hardware and software technologies for asset management. Although, from a technical and regulatory/regulatory point of view, it is feasible to implement and manage collective self-consumption and Energy Community schemes without the introduction of additional metering devices and energy asset monitoring/management systems, operators emphasize that it is their intention to install non-fiscal metering devices in order to have direct and "close to real

time" visibility on consumption and production data and collect them in a platform that performs at least the "basic" monitoring function, up to more advanced functions of asset management/optimization and dispatch order allocation in case the Community participates in flexibility mechanisms

For each of the 3 identified business models, two sub-cases can be distinguished, depending on the bundle of technologies that characterizes the Energy Community Developer's offering.

For example, relative to an "asset installation" activity, we may have:

Basic asset

- Photovoltaic system is the only technology provided.
- The supply activity is understood to include sizing, the design, operation and maintenance of the plant.

Premium asset

- The Energy Community Developer's supply includes the photovoltaic system, storage, and electric vehicle charging infrastructure.
- The supply activity is understood to include sizing, the design, operation and maintenance of the systems.

4.2.1 Basic sharing model

Model in which a third party is responsible for researching and aggregating the members of a community, rather than the condominiums residing in the same building, and installing both the assets and the management hardware and software technologies necessary to activate the community.

Specifically, the entity proposes a basic offering to provide the Community with only the PV system, ensuring its sizing and design and subsequent management over its lifetime.

In addition, the proposed technologies include additional metering devices, which are functional for both the collection of production data of the photovoltaic plant and consumption data of the POD offtake utilities included in the Community. The collected data flows into the centralized platform through which the Energy Community Developer can monitor energy flows.

It does not offer additional energy optimization and efficiency services, nor does it intend to enable the configuration to participation in the MSD.

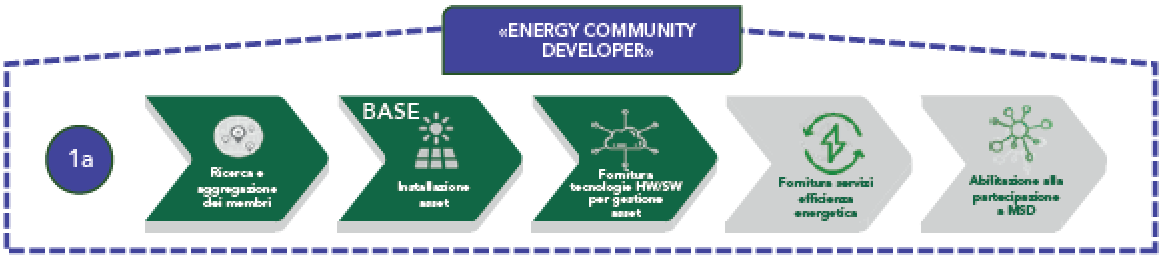

Figure 9 - Basic sharing model [9]

To identify the key points of the business models described above, the main information characterizing each of them is given in a simplified diagram of the Business Model Canvas (figure 10).

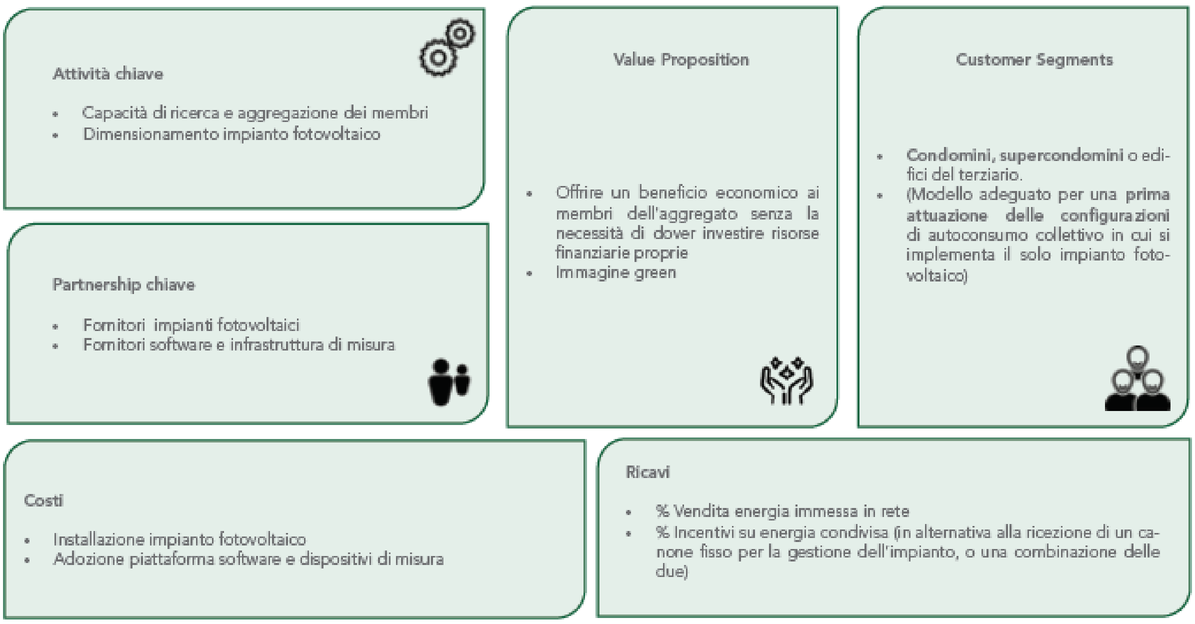

Figure 10 – Basic sharing model – Business Model Canvas [9]

4.2.2 Premium sharing model

Version "b" of the first business model is differentiated by a "premium" asset offering, which enables the possibility of creating a more technologically advanced configuration, in which in addition to the photovoltaic system there are storage systems and electric vehicle charging stations.

Thanks to the presence of storage, and with the support of a software platform that in addition to monitoring is able to perform optimization operations (and possibly forecasting), energy storage activity is enabled and charge/discharge management strategies can be implemented to maximize the share of shared energy and consequently the obtaining of incentives.

The activities of the Energy Community Developer, in this model, do not result in the provision of other energy efficiency services or participation in the MSD.

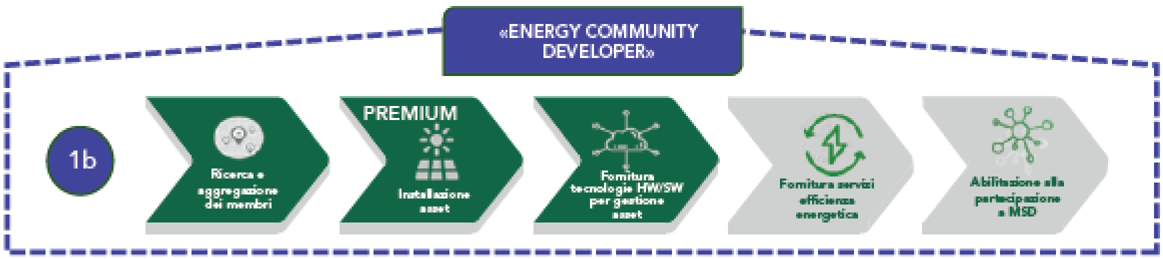

Figure 11 - Premium sharing model [9]

To identify the key points of the business models described above, the main information characterizing each of them is given in a simplified diagram of the Business Model Canvas (figure 12).

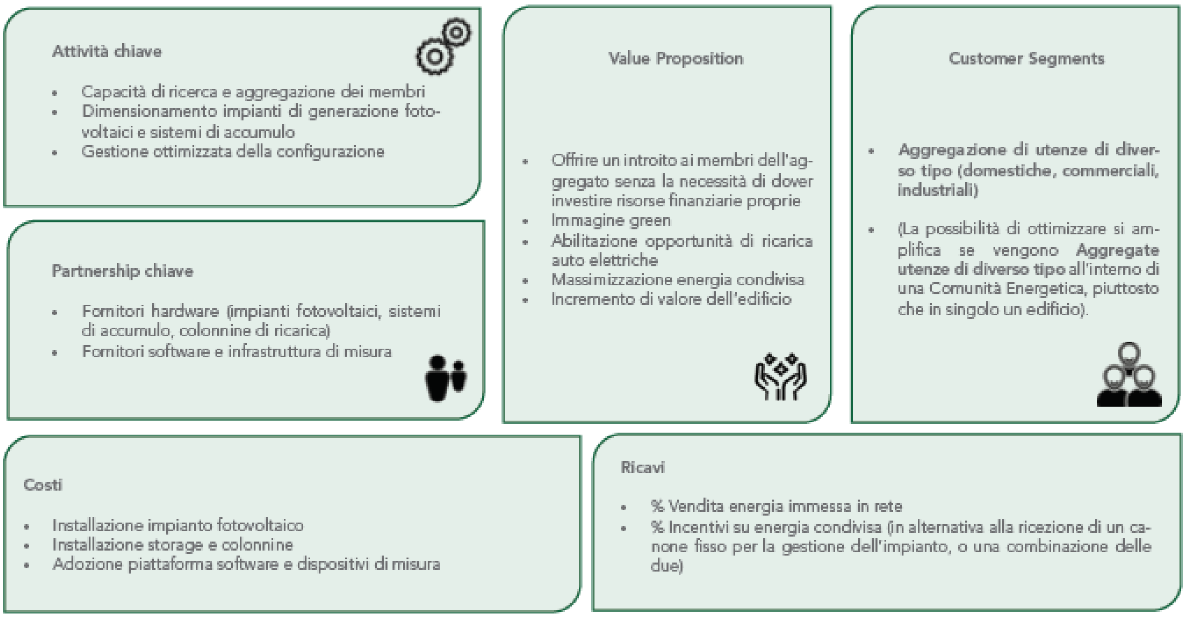

Figure 12 - Premium sharing model – Business Model Canvas [9]

4.2.3 Basic services model

Under this business model, the Energy Community Developer who promotes the creation of the Community is responsible for installing the PV system, measurement devices, and monitoring platform.

He/she can also propose energy efficiency interventions to the consumer users included in the configuration (whether residential, industrial, tertiary or PA), even at a later stage, taking advantage of the energy data collected and processed by the platform.

The creation of the Community thus represents for the Energy Community Developer a "flywheel" for the activation of further services, which can be activated at a later time and with investments that follow different business models. The presence of the Energy Community Developer as the sole interlocutor of the community allows for the exploitation of the "synergies" associated with the provision of these services in a joint manner (with related general savings for users), as well as (for the Developer himself) benefiting from an additional source of revenue.

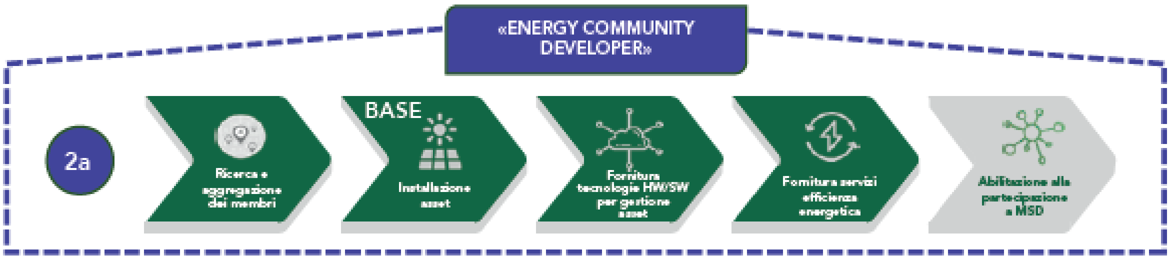

Figure 13 - Basic services model [9]

To identify the key points of the business models described above, the main information characterizing each of them is given in a simplified diagram of the Business Model Canvas (figure 14).

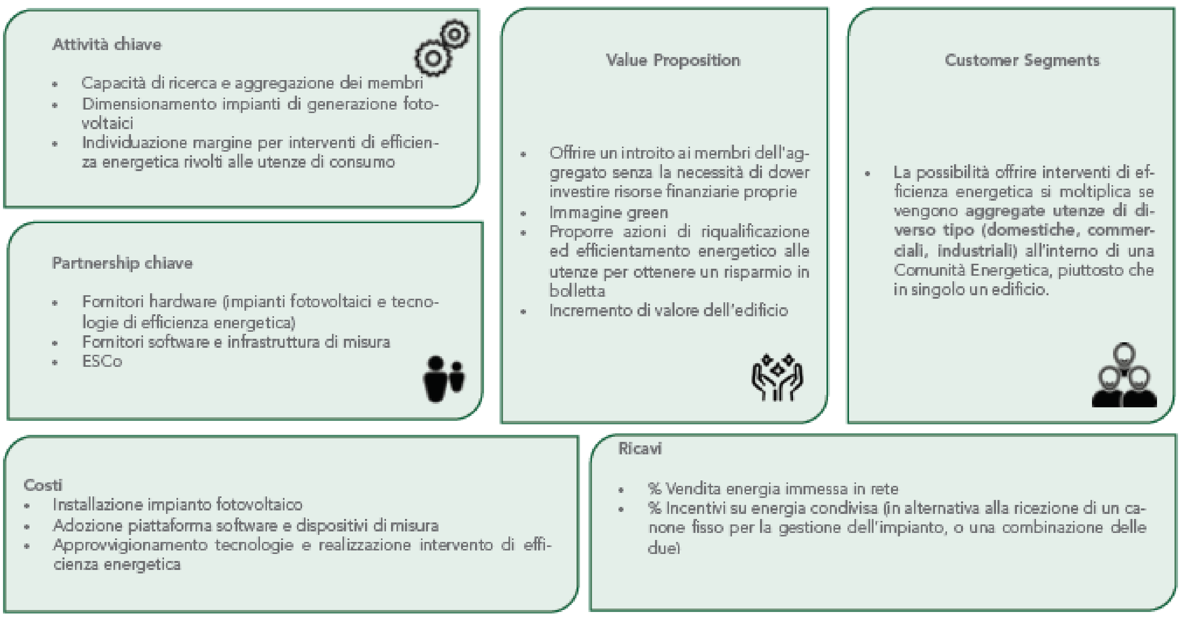

Figure 14 - Basic services model – Business Model Canvas [9]

4.2.4 Premium services model

In this business model, the Energy Community Developer also offers electric car storage and charging technologies in addition to generation facilities.

This allows for more "push" optimization by leveraging the Energy Management platform.

Within the "services" business models (both 2a and 2b), the presence of the metering devices and the platform turn out to be key elements for proposing energy efficiency interventions or actions to customers and giving evidence of the savings achieved, thanks to the possibility of comparing consumption pre- and post-intervention.

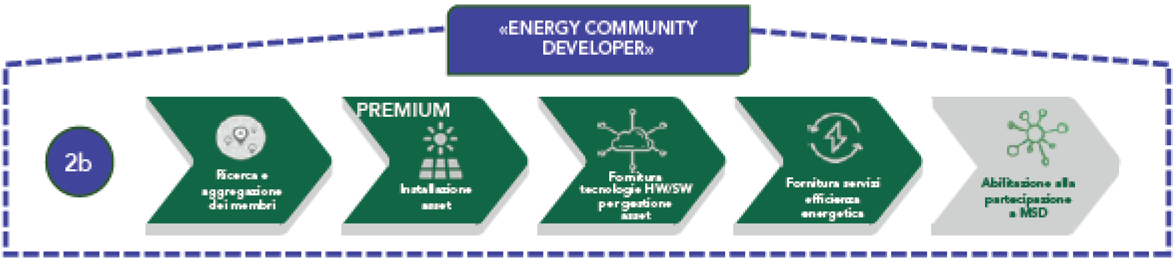

Figure 15 - Premium services model [9]

To identify the key points of the business models described above, the main information characterizing each of them is given in a simplified diagram of the Business Model Canvas (figure 16).

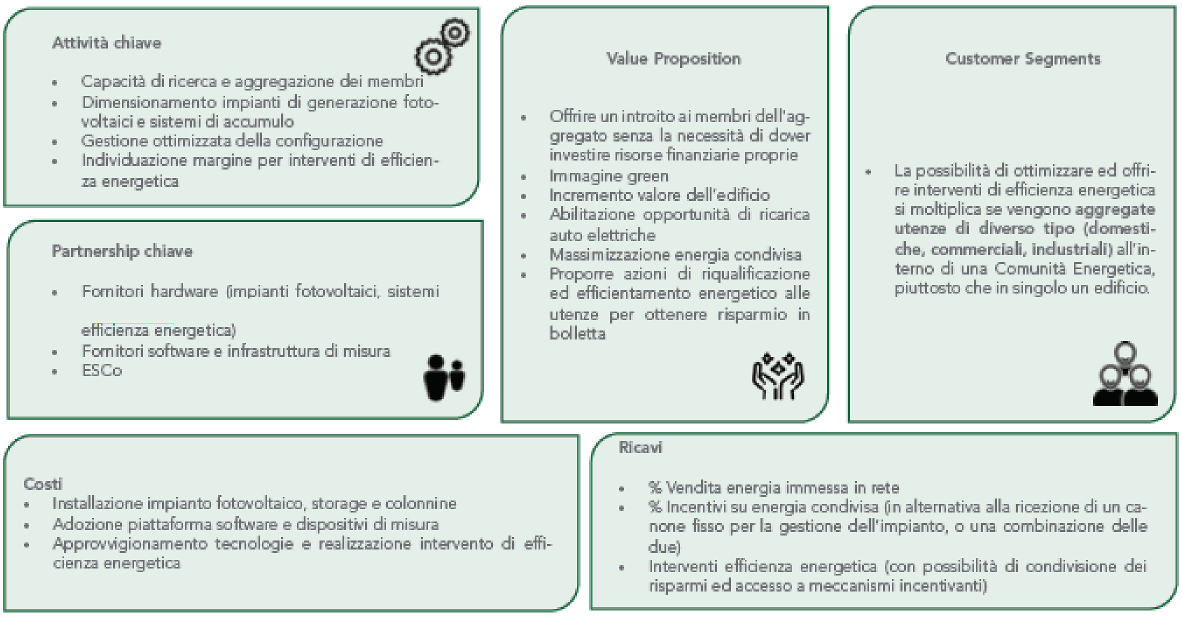

Figure 16 - Premium services model – Business Model Canvas [9]

4.2.5 Basic MSD model

The last business model identified is one in which the Energy Community Developer, in addition to optimizing the energy variable within the community (energy sharing and energy efficiency), proposes to the community participation in flexibility services, taking advantage of the available resources, which in this basic case coincide with the photovoltaic plant and consumer utilities.

The development of this level of business model can be expected only after a certain period of experimentation with collective self-consumption configurations, but already this outlet for these projects can be expected. Integrated resource management and monitoring, in fact, allow control of resources that, aggregated, can provide a relevant margin of flexibility to the network.

Participation in the MSD is through a BSP that has the necessary technological infrastructure.

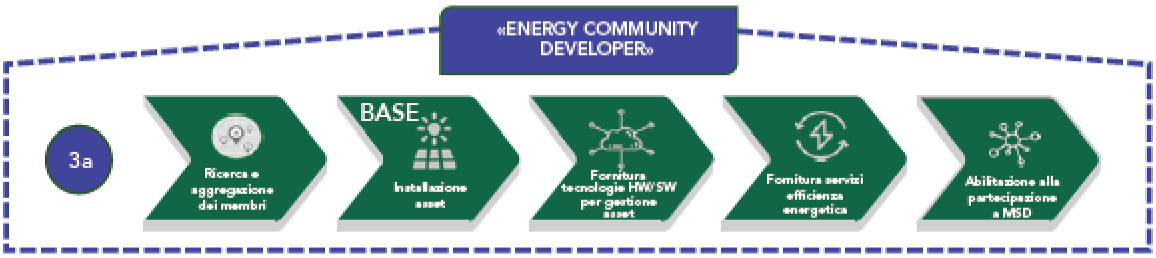

Figure 17 - Basic MSD model [9]

To identify the key points of the business models described above, the main information characterizing each of them is given in a simplified diagram of the Business Model Canvas (figure 18).

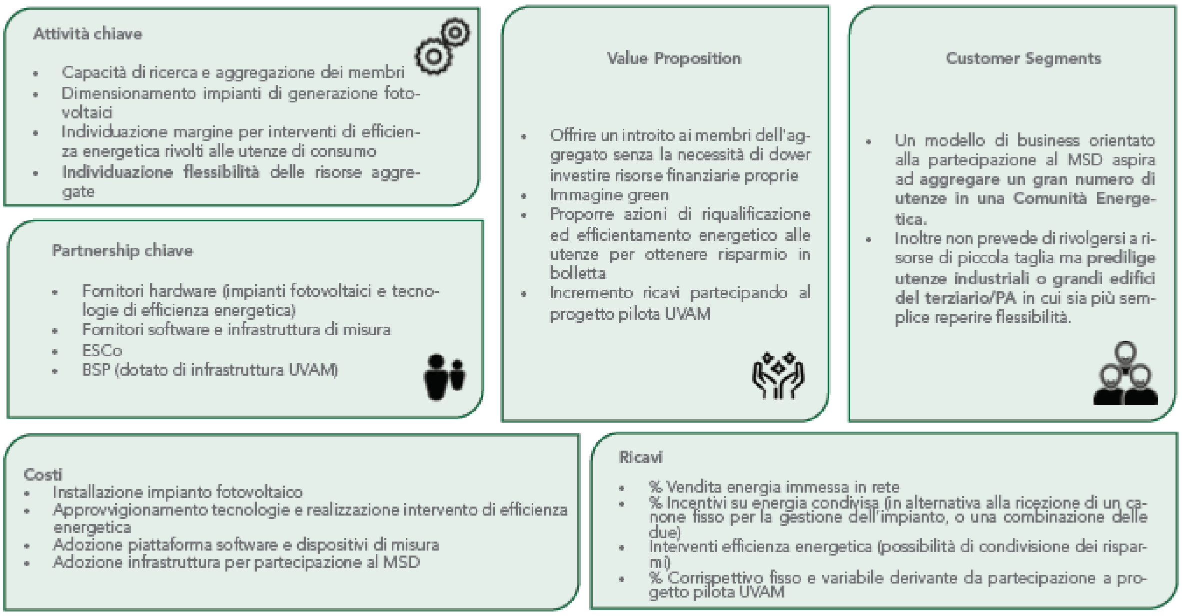

Figure 18 - Basic MSD model – Business Model Canvas [9]

4.2.6 Premium MSD model

Similar to the previous case, the Energy Community Developer is able to take advantage of the flexibility of the resources underlying the configuration and enable participation in the MSD. Compared to the base case, there are more "flexible" technologies involved: in fact, one is not limited to consumption modulation but also has storage systems and charging stations.

So, in this business model there is an opportunity to make the most of resources, both in terms of optimizing shared energy and in terms of providing flexibility to the system.

In order to "capture" all the revenue opportunities that exist, it is essential to have a technological infrastructure, specifically a platform, capable of making economic evaluations that go to identify the asset use option that is most convenient to implement in a certain time interval, comparing possible alternatives with each other and receiving market data as input. In addition, in order to implement these kinds of "advanced" management strategies, a key element is the presence of tele controllable assets that implement the set points sent by the platform.

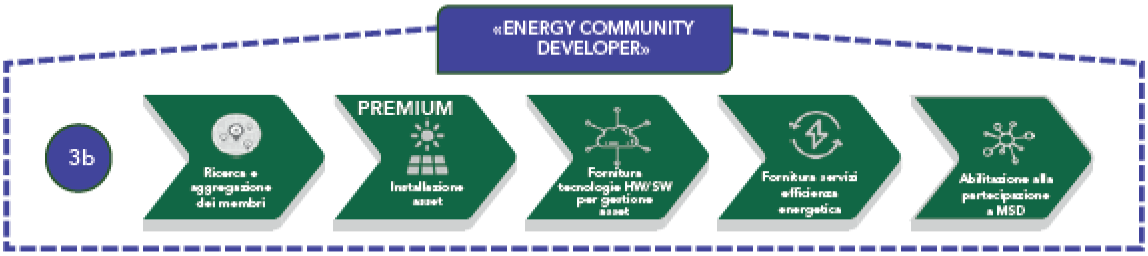

Figure 19 - Premium MSD model [9]

To identify the key points of the business models described above, the main information characterizing each of them is given in a simplified diagram of the Business Model Canvas (figure 20).

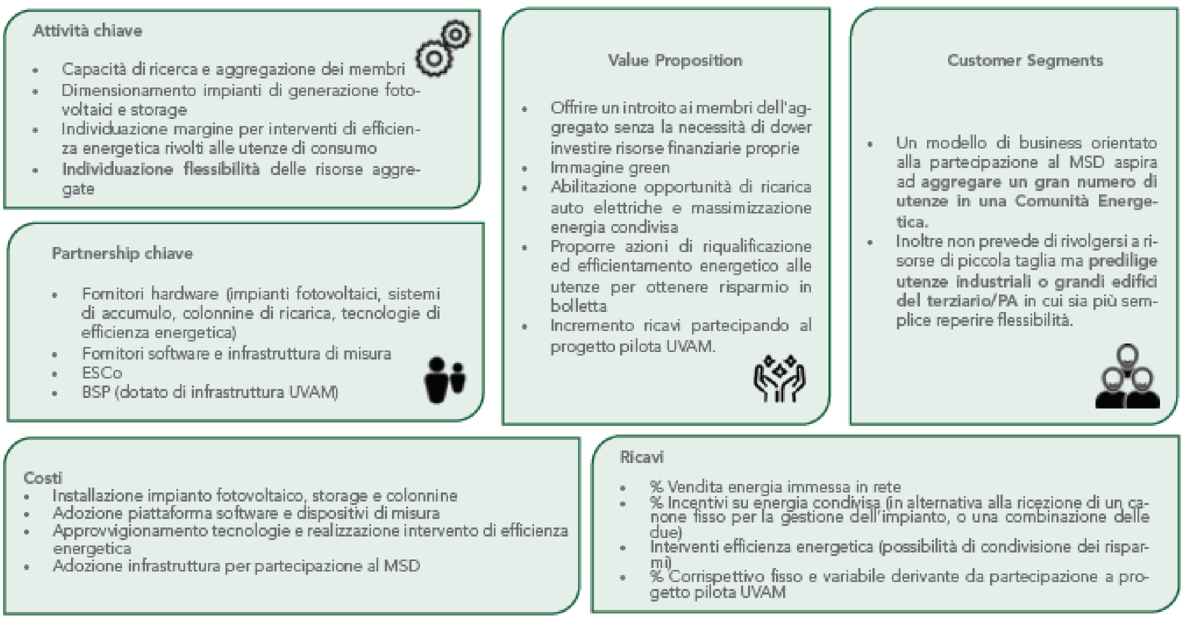

Figure 20 - Premium MSD model – Business Model Canvas [9]

4.3 The breadth of supply

Based on the interactions with major players in the industry, a clustering of the players under empirical investigation is proposed with respect to the different business models analyzed.

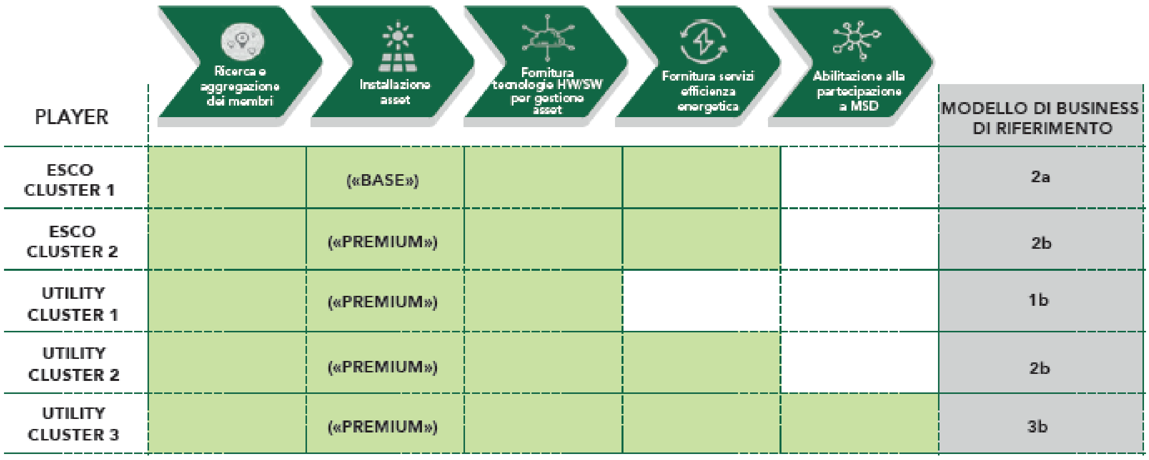

Figure 21 – Clustering of the players respect to the different B.M. [9]

The empirical analysis shows a multiplicity of business model articulations currently under consideration to promote initiatives in the area of collective self-consumption of renewable energy and energy communities, recently enabled within the Italian context.

The 6 business models identified differ primarily on the basis of the activities that an Energy Community Developer manages within its business model and the portfolio of technologies offered.

In a strongly changing context, the main "sticking points" appear to be the following:

- All business models cover the activities of finding and aggregating members and providing the hardware and software technologies for managing the assets present.
- All business models include (at least) the provision of basic technologies for the generation in on-site power generation (photovoltaics).

What emerges from the interviews conducted with the players is a substantial intention to offer configurations of collective self-consumption of renewable energy and energy communities the opportunity to install the "premium" package of technologies, which in addition to the PV system also includes storage systems and charging stations.

However, the entire sample of interviewees emphasized that at an early stage of development they are willing to install the PV system and possibly consider later the annexation of a storage system and charging stations.

This would make it easier and more immediate to "activate" the configurations.

Thus, business models 1a and 3a do not turn out to represent the business model to which operators tend and that they actually intend to offer customers, however, they may find application at an early stage of Community development during these first months of experimentation.

The exception is model 2a, which appears to be of reference for some ESCos that focus the concept of Communities on the opportunity to aggregate a group of local users through the possibility of making a common investment in a green technology and offer them energy efficiency services aimed at generating bill savings. The Community in this case is primarily an opportunity to gain access to users' consumption data through installed monitoring systems and offer them targeted solutions. These activities are most appropriate for large users (from the tertiary or industrial sectors) or to even small users but located in the same building.

Business model 1b, unlike 2b just described, has as its main objective the creation of the energy community or collective self-consumption to capture the revenue opportunities inherent in the scheme, rather than focusing on the "complementary" services of energy efficiency and participation in the MSD. It appears of interest especially to those utilities that intend to initiate or consolidate a relationship with utilities regarding energy supply.

The business models that operators are most likely to implement turn out to be those that also include the provision of additional energy efficiency services (model 2b), an activity that is "core" for ESCos but is also becoming increasingly relevant for utilities, which over the years have developed an energy efficiency division internally with internal resources and/or by taking advantage of M&A transactions having as "target" ESCos active in the market.

Dwelling on the activity of participation in the MSD, a substantial "uncovering" of this phase emerges, as it is not currently considered a priority by operators, but the subject of a later evaluation, when the Energy Community is operational and "in full swing." Only in cases where the Energy Community Developer already has experience as a BSP due to past participation in the UVAM project, it is likely that the offer may include the possibility of including this activity in the perimeter of the Community's expertise.

Transversely to the different business models, the important role played by technology providers as "enabling" partners of the different business models emerges.

5. Energy communities: how energy bigwigs deal with the issue

The energy revolution has begun. Now impossible to turn back, more and more territories, administrations, citizens and companies are on the move in setting up new experiences of self-production, self-consumption and energy exchange, despite the eagerly awaited completion of the process to transpose the European directive. At least 30 have been surveyed by Legambiente, including configurations of energy communities from renewable sources and experiences of collective self-consumption, in a movement that is anything but slow, in spite of the installations of large plants, which are once again struggling to take off.

Numbers that tell well not only of the great interest in these new opportunities that have arrived with the experimentation permitted by the Milleproroghe Law approved in March 2020, but also of the need and desire for protagonism from below capable of involving entire territories in new 'energy adventures'.

A trend already recounted in these 13 years of the Report in which Legambiente wanted to highlight not only the quantitative evolution of renewable sources in the territories, but also the energy innovation that has made hundreds of companies, enterprises and administrations protagonists in recent years, and partly recounted in the Map published on the website comunirinnovabili.it where more than 300 projects are collected and from this year also accompanied by the web application dedicated to energy communities.

A tool created to allow the curious to virtually navigate among the different realities and discover their advantages and characteristics.

5.1 Energy bigwigs' viewpoint

How are the major players in the national energy sector working on Renewable Energy Communities?

Something clearer emerged at the conference 'Energy Communities - Economic Development Leverage for Transition', held at the Politecnico di Torino.

The conference was promoted by IFEC, which stands for Italian Forum of the Energy Communities, an emanation of the Italian section of the World Energy Council (WEC) that aligns the Italian representatives of the major international energy players in its governance.

The chairmanship of WEC is entrusted to ENI, and two of the three vice-chairmen represent Enel and Edison. A partner in the initiative is the Energy Center of the Politecnico di Torino, whose Advisory Board is in turn made up of the three aforementioned operators, in addition to Terna, IREN, local and regional public administrations, such as the Municipality of Turin and the Piedmont Region, and research bodies such as ENEA, RSE and the EU Joint Research Center.

The main topic was focused on the prospects opened up by the final transposition of Directives 2018/2001 and 2019/944.

Also present were mayors and representatives of Local Authorities who, with the Energy Center, have undertaken experimentation paths of Renewable Energy Communities (RECs), mainly in Piedmont and Friuli Venezia Giulia.

Paolo Arrigoni, a member of the 13th Permanent Commission of the Senate, emphasised that it is the municipalities that must play a leading role, together with citizens and SMEs, and that it is the task of mayors to be the facilitators and developers of energy communities, paying attention to maintaining the benefits on the ground.
The final transposition of the RED II directive, we recall, raises the power per installation to 1 MW and expands the scope of RECs to the primary cabin.
Research, training and environmental protection organisations will also be able to participate in RECs, as well as third sector and religious organisations.
Even if we will have to wait at least until the summer for Arera's provisions from the MiTE, from now on there is a concrete possibility of designing large area energy communities.
In fact, if with the secondary cabin limit one could aspire to RECs of 60 or 70 members, the primary cabin could also include RECs of 10,000 to 15,000 members, spread over several municipalities, who can make incentivised extended self-consumption.
Prompt planning will be instrumental in intercepting PNRR funds: 2.2 bn/€ earmarked for municipalities with a population of less than 5,000 inhabitants to set up Renewable Energy Communities.
In this scenario, it is necessary to note the extreme fragility of the Local Authorities that are called upon to lead the process due to their scarce human resources and skills. Municipalities with two or three employees will hardly be able to design CERs autonomously, all the more so since EU funds, hence the PNRR, reward territorial aggregation and the harmonisation of interventions.
Starting from this weakness, therefore, the great challenge is to intercept the enormous amount of money at stake with large-scale projects and translate it into a business opportunity for economic recovery, but maximising the benefit for local communities.
As Gianluca Fulli, of the European Commission's Energy Security, Distribution and Markets Unit, has well emphasised, business models, in fact, must generate a

favourable impact for communities, which must be active participants, gaining awareness while protecting and, at the same time, emancipating the vulnerable.

From this scenario, which is then that of RED II, all geared towards undoing the laces and ties to make energy, both renewable and human, too long suppressed thanks to liberalisations that have remained unfinished, brings us back down to earth the all-political intervention of Giuseppe Montesano, Deputy Director of the Enel Foundation, IFEC's founding partner.

Montesano notes as problematic the fact that tax benefits today favour plant ownership by REC members, rather than service providers.

Moreover, incentives should not be limited to small plants (<1 MWp) because, he says, this is a strong constraint on the development of Energy Communities. Moreover, with respect to the perimeter of ECs, also to facilitate accessibility of information, Enel's position is to favour the postcode (postcode) rather than the primary cabin.

Finally, Montesano emphasises the primary role of DSOs in facilitating the optimal integration of RECs in the energy system, to enable their development, especially, he says, 'if they are integrated in networks managed by technologically advanced companies, particularly in the field of digitalisation'.

In a nutshell, it is my understanding that Montesano suggests that the simplest and most effective solution would be to entrust the management of RECs to 'evolved' electricity distributors, allocating incentives and tax benefits to companies rather than to Community members, and extending them to large plants.

In the alternative, he re-proposes the use of the CAP, which is necessary to solve the problem of data accessibility, which is nevertheless a right of users, thus fragmenting the RECs again with respect to the primary cabin.

All this without mentioning E-distribuzione (DSO) or Enel X (REC enabler), but somehow fully describing his own reference company, ENEL.

In general, the so-called 'facilitators' are moving towards business models that tend towards 'turnkey', supporting both private individuals and local authorities, working on design or in areas already defined with the provisional transposition of the Directive.

This is the case of Edison, which is currently focused on collective self-consumption (AUC), an area in which it has created an offer in partnership with Gabetti Lab aimed at condominiums.

It is Edison that builds and finances the system, giving the customer a benefit that consists of savings equivalent to two bills/year and that can increase up to 50% of the value of the bills to the extent that the customer participates in sharing the self-produced energy.

The next step will be the aggregation of condominiums into Energy Communities to be managed together with local public administrations.

The start-up phase of Eni's repositioning, on the other hand, took place through the acquisition of Evolvere and My Solar Family, two companies that enabled Eni to sign a memorandum of understanding with the municipalities in the south-east area of Milan, where it has its headquarters, to support the PAs in the phases of construction, definition of ideas, models and plans for the economic and financial feasibility of RECs and, finally, management and eventual supply of storage systems.

Then there are the experiments followed by Politecnico di Torino’s Energy Center where the watchword is replicability.

Like Edison, Acea Pinerolese Energia, which was initially involved in the creation of a wide-area energy community in accordance with the regional law of Piedmont (see The Pinerolo energy community and the regulatory ambiguities that are hindering it), has subsequently opted for the development of collective self-consumption groups

(AUC) in apartment blocks, which it combines with energy efficiency, building automation systems and electrification of consumption, also acting as an ESCo.

Five AUC groups are currently implemented and registered, while another five are unable to start due to difficulties with DSOs in connecting the plants. Acea's project is of course scalable and replicable.

Marco Bailo, Mayor of Magliano Alpi and architect of the first Energy Community, urges his fellow mayors to replicate his experience. The creation of CERs in territories other than his municipality, he said, has always been his goal.

To this end, the Municipality of Magliano Alpi has entered into agreements with municipalities even outside the Piedmont region, based on Art. 15 of Law 241, which states that 'public administrations can always conclude agreements among themselves to regulate the collaborative performance of activities of common interest'.

Comunità Collinare del Friuli (CCF), which groups 15 municipalities and is configured as a local authority according to the legislation of the Autonomous Region, in turn makes itself available to share its experience with other territories.

Luigino Bottoni, president of the CCF, confirms the difficulty of small municipalities in facing the path of building a REC and the strength that the aggregation of several municipalities assumes instead. It should be noted that the municipality of San Daniele formed the first REC in Friuli.

As part of the RECOCER project, with the technical-scientific support of the Energy Center of Politecnico di Torino, a steering committee was set up that will contribute to the creation of technical-managerial capacity within the Collinare Community for the establishment and management of RECs and CSCs in the territory of the 15 municipalities.

5.2 Case study: Hera

With the aim of being a partner for its customers to help them in their path of energy transition, Hera Comm finds it consistent to offer solutions that help the spread of Energy Communities throughout the territory.

Hera Comm wants to exploit the experience it has acquired in the photovoltaic field to offer services relating to new production and consumption configurations, known as Energy Communities. In recent years, in fact, thanks to the acquisition of a company active in the design and construction of photovoltaic systems, Hera Comm has enriched its portfolio of services with offers dedicated to those who want to become prosumers, acquiring the know-how necessary to build a "turnkey" offer for its customers.

Following the transposition of European Directives, legislation was also introduced in Italy to define and regulate the operation of Energy Communities.

The novelty and the various opportunities that may arise from them have led most Italian energy players to delve into the subject, in order to acquire the necessary know-how and to be able to propose suitable solutions to manage the technical-regulatory and administrative complexities that come into play.

Pursuing precisely this objective, Hera Comm is developing two pilot projects focused on the simplest form of Energy Communities, that of Collective Self-consumption within the same building. In both experiments, a photovoltaic system will be installed on the roof of a block of flats, allowing physical self-consumption by the POD of common uses and virtual self-consumption by individual flats.

The apartment buildings are located in the municipalities of Bologna and Casalecchio di Reno, are of comparable size, with about 20 flats each, and have an architecture that allows the installation of a 19.5 kWp.

The main objective of the two pilot projects is to acquire the know-how necessary for the start-up and management of an Energy Community type configuration.
This know-how is not unique, but can be declined in different aspects.
In an initial set-up phase, which includes all the activities necessary for the formal realisation of the Community, it is essential to understand the target customers to whom this set-up should be proposed, and to identify the optimal partners for the realisation of these projects.
Hera Comm's experience has underlined some points of attention directly related to this phase, which mainly concern the identification of a condominium administrator who is open to dialogue and willing to involve his or her clients in this type of initiative.
A further step to emphasise concerns the identification of a condominium, among those managed by the selected administrator, that is suitable from two points of view: structural characteristics, thus allowing the installation of a sufficiently sized photovoltaic system, with a favourable orientation and as much shading as possible, and the propensity of the tenants to develop the configuration.
Also with regard to this initial phase, the type and correct sizing of the system must be understood from a technical point of view.
A number of obstacles, of different origins, were also encountered for the activities related to the acquisition of this type of know-how. First of all, we have the issue of correct plant sizing: since Energy Communities have only recently been introduced, best practices are not yet widespread to unambiguously find the optimal plant sizing to serve the Community.
This is in fact much more complex than the case of a plant serving an individual, as the stakeholders of the initiative are more numerous, with heterogeneous characteristics and interests. Secondly, difficulties were encountered in the retrieval of

consumption data of individual potential members, necessary for the correct sizing of the plant.
These barriers affected both existing customers, due to a lack of hourly data linked to the incomplete diffusion of 2G meters in homes, and non-customers who, despite a preliminary information campaign by Hera Comm and condominium administrators on the experimental project, showed some resistance to sharing their consumption data or to providing them in minimum detail (i.e. annual consumption value per band). In parallel with the identification of the correct plant sizing, in order to elaborate a service proposal for the Community, it was necessary to understand the technical-administrative activities to realise the configuration: Hera Comm's objective is to assist the Community in all the necessary fulfilments not only for the commissioning of the plant or taxation, but also for the formalisation of all the necessary acts with the GSE.
A Community is in fact required to draw up a 'deed of incorporation' that regulates relations between members and formalises the constitution of the configuration. Together with this, the Configuration Referent will have to fill in the formats made available by the GSE to communicate all the information relating to plants and utilities within the perimeter of the Community, to be mandatorily uploaded on the GSE portal. Finally, with regard to the post-start phase, Hera intends to acquire management know-how.
This refers to all those activities that ensure the proper functioning of the Community and mainly concern the obligations towards the GSE and the members themselves, such as the reporting of the energy balance for the calculation of shared energy, the receipt of the relevant economic incentives and their subsequent distribution among the Community members.
A further aim is to test technological components complementary to the photovoltaic system. Particular reference is made to the use of bi-directional storage systems that, recharged with the energy produced by the plant, allow the subsequent feeding of the stored energy into the grid, thus contributing to virtual energy sharing. Closely linked

to these devices is the implementation of energy management platforms. These products enable various functionalities, including: monitoring of energy flows, gamification and active involvement of members, optimisation of flows and shared energy. Their implementation in pilot projects is therefore aimed at verifying their real added value within these configurations.

For each of the apartment buildings covered by the pilot project, the analysis of energy consumption and the study of the buildings' architectural structural constraints identified the installation of a 19.5 kWp photovoltaic system as the most suitable solution. This will be accompanied by a 15 kWh storage system, directly connected to the system. Finally, the hardware required to operate the Energy Management platform will also be included.

The latter consists of a central intelligent meter, which allows both the monitoring and control of energy assets and is connected directly to the system's inverter; in addition to this, there are meters installed in the individual homes within the community.

The proposal to the condominiums consists of the turnkey design and installation of the solution, through the sale of the photovoltaic system to the condominiums, benefiting from tax deductions, and taking care of all the paperwork to the GSE to obtain incentives, with discounts that minimise the barrier to entry, to favour the course of the experiment, in exchange for sharing the economic value of the shared energy.

The decision to carry out pilot projects on Energy Communities came in early 2021, after the full publication of the legislation, albeit transitional, which allowed for adequate knowledge of the context. The complexity and novelty of the topic led to the study of virtual self-consumption in condominiums, which is the simplest case of an Energy Community.

The implementation process began with the identification of the two condominium administrators 'sponsoring' the initiative and the subsequent identification of the condominiums, according to the criteria described above.

This was followed by the analysis of consumption and studies, including technical inspections, aimed at defining accurate estimates, which also included extra works and variants.
In addition, contacts were made with several players supplying Energy Management platforms and, after identifying the most suitable, the supply characteristics were finalised. At the same time, various commercial propositions were analysed with the aim of minimising the end customer's cash-out.
The proposal was then presented to the condominium administrators, who will proceed to communicate it to the tenants. As a final step, the condominiums will have to meet in an assembly in early 2022 and deliberate on the proposal, simultaneously establishing the Community.
The implementation of a Self-Consumption Collective configuration will bring several benefits to the inhabitants of the two apartment blocks covered by the pilot project. During the investment phase, in addition to a discount dedicated to the project, the condominiums will be able to benefit from 50% tax deductions as provided by the regulations, which will further reduce the economic commitment required. Preliminary simulations carried out show that the photovoltaic system will make it possible to achieve around 60% self-consumption (physical and virtual) within the community.
The apartment blocks will thus be more independent with respect to the public grid and will supply their needs with clean energy produced directly on their roofs, with the respective environmental benefits that follow. Moreover, also thanks to the use of the platform, the cohesion of the members and the sense of belonging to a group will be stimulated, thus also generating social benefits.
Of course, there will also be economic benefits in the form of: bill savings due to self-consumption; sale of energy fed into the grid; and receipt of the shared energy incentive from the GSE.

5.2 Case study: A2A

A2A Energy Solutions is the A2A Group's company that offers energy efficiency solutions and is the partner for companies and apartment buildings that want to realise the Energy Transition in respect of sustainability.

They are active in the field of Energy Communities with the first experiments to test the mechanism aimed at incentivising widespread self-production from renewable sources and increasing citizens' awareness of energy issues with the belief that this is an important tool for pursuing the goal of decarbonising society.

The ECOCITY Collective Self-Consumption project stems from the desire to create a building complex with very low polluting emissions, capable of minimising energy use and expenditure.

Working alongside the builder, Impresa S.IM.CO. srl, A2A Energy Solutions worked with its partner SunCity to provide the technical and management solutions for the realisation of the photovoltaic system and the Collective Self-consumption initiative. The project is being realised in Tortona (AL) on a new building, a tower block, the first of two twin buildings of 8 floors above ground, built with all the constructive devices aimed at minimising energy consumption and maximising comfort conditions: envelope adhering to the best standards of thermal insulation, winter and summer condominium air conditioning systems with geothermal heat pump, mechanical ventilation systems with heat recovery.

The building does not use gas, is totally electrically powered, and induction hobs are used for the kitchens. Consisting of 29 residential units plus 400 square metres for commercial/service use, the building has a single roof pitch to accommodate the greatest possible photovoltaic power, with an ideal inclination and orientation that maximises energy production throughout the year.

The photovoltaic system is composed of 200 Jinko Solar photovoltaic modules of 340 W each for a total power output of 68 kWp and an estimated annual producibility of about 75,000 kWh/year, and is connected to the electricity grid on the same meter as the common condominium utilities to get the maximum benefit from instantaneous self-consumption.

The system is complemented by a Huawei inverter, a 30 kWh LUNA2000 electrochemical storage system that decouples photovoltaic production from utility consumption, and a 22 kW Newmotion electric vehicle recharging station placed at the exclusive service of the condominiums.

The Self-Consumption Collective initiative is realised at the will of the builder, not only to exploit the economic and plant engineering advantages obtainable with this set-up, but also to respond to the demand for involvement and concrete actions that the new generations in particular are seeking on environmental and sustainability issues.

Advantages for the manufacturer

- Possibility of realising a very efficient system that reduces the investment thanks to the single photovoltaic system operating at the service of both the common condominium utilities and all the building units (instead of realising many systems each serving a single unit) with a consequent reduction in plant engineering and management complexity and a reduction in operating costs occurring over time.
- Differentiation and valorisation of the real estate product due to the great value perceived by the client in terms of energy efficiency and sustainability.

Benefits for condominium owners benefiting from the CSC configuration

- Reduced energy expenditure: economic advantage (incentive and other advantages on transport charges and losses) of approximately 108 €/MWh on the share of energy produced and consumed collectively, in addition to the advantage of not withdrawing energy from the grid through instantaneous self-consumption on common condominium utilities.

- Greater awareness and involvement of condominium owners with respect to the impact of their actions on energy consumption and consequent virtuous behaviour aimed at maximising collective self-consumption.

Figure 22 - Photovoltaic system on the roof pitch of the 'Ecocity' building in Tortona (AL)

Figure 23 - Construction of the twin buildings that make up the 'Ecocity' complex in Tortona (AL)

If the experimentation carried out on the first Collective Self-consumption initiative is successful, the Ecocity twin tower will also be completed with the same configuration. Suncity (A2A Business Partner), a reference point in the field of energy efficiency, and IMPRESA21, a promoter of a new business culture, are proposing a first energy community project in the small Abruzzo village of Gagliano Aterno.

The municipal area made available is the Antico Fontanile, which will see the construction of a 20 kW photovoltaic plant. In recent months, the municipality has received technical and organisational assistance for the following phases: establishment, plant construction and community management.

The numerous inspections have brought to light the entire built-up area, the morphology of the territory, and the landscape and archaeological constraints. The first phase of the work saw the identification of all the dwellings in the area, served by the same MV/LV electrical substations. Subsequently, meetings were held with the entire citizenry to explain in detail the benefits for those interested in participating.

To date, the work progress sees the installation of the plant in the fountain area, work that will give a new function to the entire area, both from an energy and environmental point of view. Subsequently, community participation accessions will be collected with or without the willingness to implement a photovoltaic plant. Once all the adhesions have been collected, we will move on to the constitution of the community and within a few months the entire plant will be connected to the grid and the GSE will be notified for the constitution of an Energy Community, whose function will not be profit but rather the benefit of all at an economic, social and environmental level, restoring the feeling of community, in which each citizen does his part for his own good and that of the entire community.

Conclusions

Energy communities constitute an innovative model whereby energy needs are met locally, autonomously, in a shared manner and through the use of renewable sources and the implementation of an intelligent infrastructure. The community envisages the active participation of all actors in the area: citizens, businesses, factories, institutions and energy producers and distributors. In Italy there have been primitive experiences of end-user involvement since the early 2000s. At present there are just over 20 (some consistent with current legislation and regulation, others sharing the spirit of the RED II and EMD directives), not counting municipalities that only use renewable energy and the fledgling Energy Community projects that are still in the embryonic stage, which aim to identify best practices. Most of the installations observed are between 20 and 50 kWp. Their actual deployment could become particularly relevant with the recent regulatory updates. Opportunities provided by public funds and benefits such as the over-depreciation, for example, are able to provide a new incentive boost and acceleration in their development and diffusion. The PNRR also provides specific funding to encourage the spread of the self-production and collective self-consumption methods described in the Italian regulations, allocating over 2 billion of euro. The investment aims to install about 2,000 MW of new electricity generation capacity in a distributed configuration by renewable energy communities and self-consumers of renewable energy. Assuming the installation of photovoltaic systems with an annual production of 1,250 kWh per kW installed, about 2,500 GWh per year would be produced, avoiding the emission of 1.5 million tonnes of CO_2 per year. Some experiences from studies and pilot projects implemented by some companies that are particularly attentive to the development of the potential of collective self-consumption and RECs have made it possible to identify some points of interest. Already realised cases especially in the field of collective self-consumption, related to building complexes with very low polluting emissions - mainly photovoltaic installations on apartment blocks - have highlighted

- advantages on the builders' side, identifiable in the reduction of plant complexity and in the valorisation of the building. The latter is increased both for the improvement of energy efficiency and for the perception of the recipient or owner of the property, gratified by belonging to a community and being an active part of a sustainable practice;
- advantages on the condominium side, identifiable in the reduction of electricity supply costs and the increase in control and awareness of consumption through the possibility of precise monitoring.

In conclusion, regardless of the completeness and effectiveness of the regulatory process, the state of advancement of the technology and the not inconsiderable involvement of citizens and PAs, made necessary by the limited knowledge of RECs and their benefits, the development of EC projects appears more necessary and inescapable than ever for independence from fossil fuel energy sources. Their deployment makes it possible to address the environmental issue, due to the possibility of supplying and increasing the use of energy from renewable sources, and the issue of energy poverty.

In this scenario, it is clear that the key role played by big energy players, like the mentioned Hera and A2A Group, becomes crucial in overcoming the barriers for ECs implementation such as the lack of bottom initiatives coming from citizens representing potential members and the technology-intensive nature of these project. The ability of large companies operating in the sector in offering the complete turnkey package ranging from support to the establishment of communities, installed technologies and attached efficiency services seems to date to be the winning model to broaden the spread of such projects and capture the enormous potential offered by such innovative models of energy production and consumption. The presence of a single actor, the so-called "facilitator", capable of covering all the activities necessary for the development of these collective consumption initiatives can facilitate the economic sustainability of the defined business models, giving on the one hand a concrete benefit to the members and at the same time remunerating the activity of the companies, which basically act as engines for the energy transition. The presence of multiple actors in fact, presents to date a potential limitation for the diffusion of such configurations. This is because the remunerability of such activities and services is not yet quantified with a complete framework, so the marginality on single activities covered by multiple individual market players might be such that the sustainability of the business is not guaranteed, in addition to the difficulty for community members to relate to a multiplicity of actors of different nature (technology providers, ESCos, Utilities, DSOs, etc.).

We expect an increasing impact from energy community and collective self-consumption configurations on the transition towards a new energy paradigm based on sharing and renewables. Like any major innovation, after an initial pilot phase, characterized by turbulence and slow diffusion given the lack of awareness on the topic, we hope to see strong growth in the development of these projects. They will play a central role in the energy revolution that is something that is necessary as well as increasingly economically viable, and it is happening right now.

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